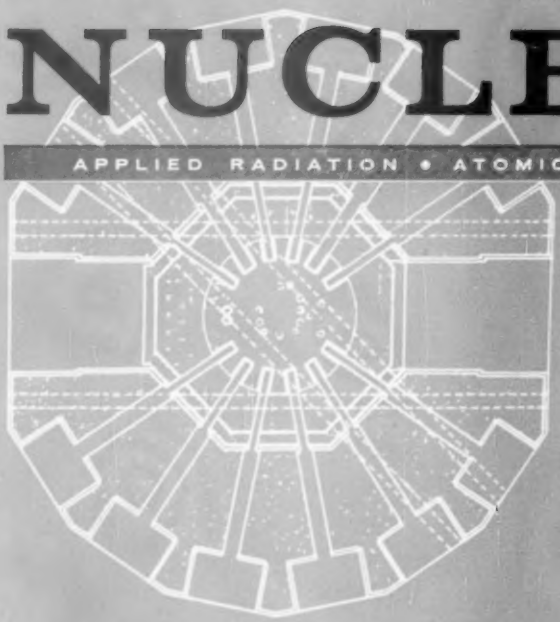
MARCH 1960

NUCLEONICS

APPLIED RADIATION • ATOMIC POWER • NUCLEAR ENGINEERING



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PAGE 82

URANIUM MONOCARBIDE —FUEL OF THE FUTURE?

Melting point, thermal conductivity and uranium density of UC are high, parasitic absorption is low, but it's brittle and corrodes readily

PAGE 74

GOING TO THE COLISEVM?

New York's Coliseum, that is, where nucleonics industry will assemble for the 1960 Atomic Exposition and Nuclear Congress

OFFICIAL EXPOSITION PROGRAM

PAGE 72a

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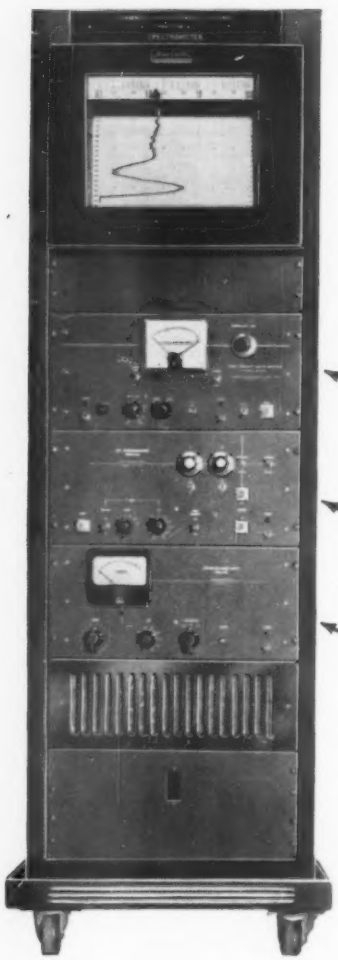

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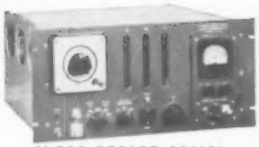

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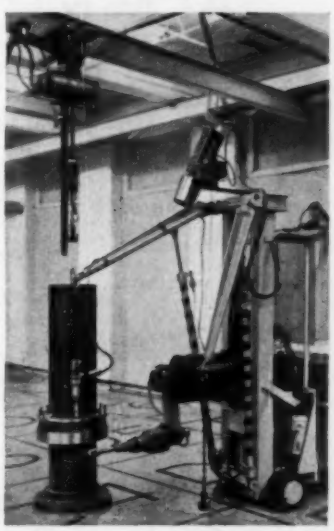
These devices are typical of many specialized components and procedures developed by Babcock & Wilcox for resolving problems in the nuclear field. Perhaps we could help you . . . The Babcock & Wilcox Company, Atomic Energy Division, 161 East 42nd Street, New York 17, N. Y.



AE-66

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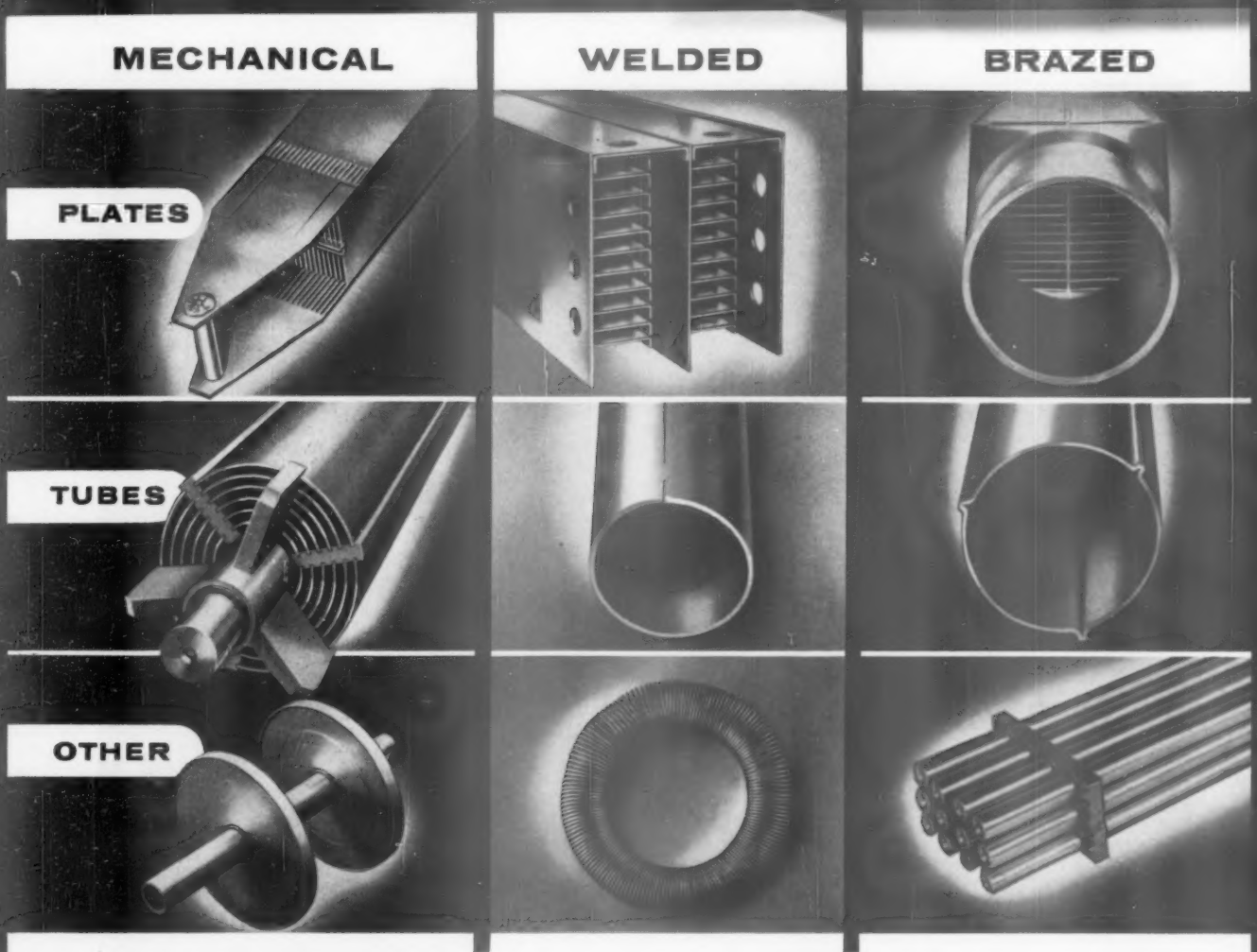

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MARCH 1960

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Radiation Chemistry of Hydrocarbons
Components for Sodium Reactors
Chemical Radiation Protection

LATER MONTHS
Scintillation Counting Symposium
More on Semiconductor Detectors
Reactors for Space Vehicles
Niobium—A Review of the Art

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...about NUCLEONICS

Welcome Back, Jim!

James J. (Jim) Dutton, whose smiling face is captured below, has rejoined the staff of NUCLEONICS. Many of you will remember Jim's earlier hitch as Associate and then Managing Editor, in the period from September, 1953 to September, 1956. That was a period of important growth for this magazine to which Jim contributed significantly. He helped set up, and was first editor for, the Nuclear Engineering department of the magazine and he organized the September, 1956 report on radiation damage, to name just two that come immediately to mind. Jim brought a background of experience as working nuclear engineer (Convair-Fort Worth) and an ORSORT graduate his first time around. Now on his return he has added experience as project engineer for the now-disbanded Bell Aircraft Nuclear Division, and, for the past two years, as Project Manager, Industrial Nuclear Fuels, for M&C Nuclear, Inc. This rich background of experience will be at work for you reporting technical developments in the nuclear field.

Welcome back, Jim!

JIM DUTTON, who has returned to NUCLEONICS as Associate Editor

New York, New York . . .

. . . *it's a wonderful town.* Those of us who work in New York and live in and around it certainly share the sentiment of the song. And we're delighted when you of the hinterland come and visit our fair city. An opportunity for just such a visit is fast approaching in the form of the 1960 Nuclear Congress and associated International Atomic Exposition to be held April 4–7.

New York's Coliseum is the scene of the Exposition this year and NUCLEONICS is providing the official program. An advance copy is included in this issue after p. 72. If you're planning to attend the Nuclear Congress, the program provides a preview of the meetings and exhibits. If you can't attend in person (try the boss again, maybe he'll relent and let you accompany him) perusing our program and the display of wares in our advertising pages is the next best thing. Note the new format for our directory of exhibitors; it's designed to help you spot those exhibitors who have something right in your field of interest.

Incidentally, we will also be supplying the 10,000 copies of the official directory that will be distributed at the Exposition itself.

NUCLEONICS is to be among the exhibitors at the Coliseum; we'll be in booth 312—please stop in and see us. One of us will be in attendance at all times, eager to talk about things nuclear and about this wonderful town of ours.

—*The Editors*

A McGRAW-HILL PUBLICATION

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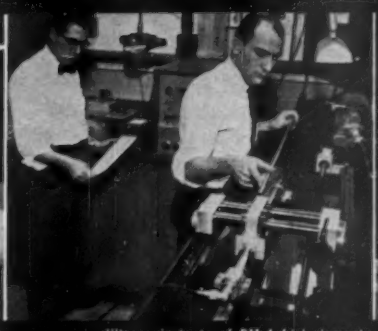
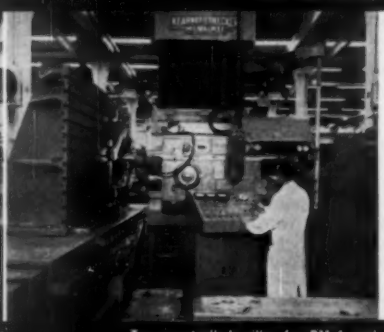

Ultrasonic tests of PM-1 fuel elements

Critical test facility

Liquid Fluidized Bed Reactor flow test

Computer used in code development


Tape-controlled miller for PM-1 grid

SNAP-3 Radioisotope-fueled generator

Cobalt 60 irradiation pool

Powder rolling for fuel element production

Corrosion test loop for EROL Program

Controlled atmosphere chamber

The Nuclear Division of The Martin Company is in its sixth year of operation in Baltimore, and has expanded considerably in the past twelve months. Current project areas include Nuclear Powerplants, Isotopic Power, Advanced Reactor Systems, Propulsion Systems, and Nuclear Components.

MARTIN

At $00^h\ 00^m\ 01^s$ GMT March 1st, 1960, Martin logged its 457,080,000th mile of space flight

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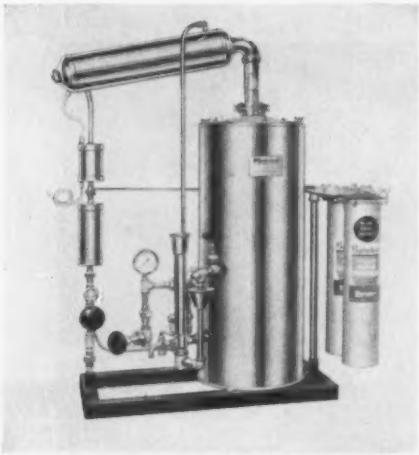

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Write for Bulletin No. 145-A.

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NUCLEAR REACTIONS

Challenge to Reactor Physicists

DEAR SIR:

During the past decade, high-speed computing machines have revolutionized reactor physics. They have permitted many laudable advances, providing answers in a reasonable time and providing solutions to problems not now amenable to simplification. However, I question the soundness of the current reliance on these machines, which I call the "machine philosophy."

In premachine days, physics was the science of approximations. Then, a physicist usually tackled a complicated problem by first analyzing an idealized model to gain insight into the problem. With this insight, he could introduce reasonable approximations and simplifications to obtain a solution.

This long-accepted and fruitful procedure is now being replaced to a great extent by the "machine philosophy." A physicist in the reactor business, as well as in other fields, uses a computer to seek a solution with a minimum of simplification. With proper programming, the answer comes out in neat printed form, and he can go on to the next seemingly more interesting problem. If he is curious, he may try to analyze the results, but why rack one's brain when another solution is readily obtainable with somewhat different input data. This lazy reasoning can be repeated time and again until mountains of numbers are generated which, because of their quantity, defy analysis.

How much insight can be obtained from such a procedure? If little or no insight is gained from the solution of particular problems, what will be the foundation for future advancement? Will not the capability for invention and discovery be thwarted?

More specifically, how much insight has been derived from the multigroup equations that are being used to calculate one, two and even three-dimensional flux distributions? Can much analysis have been performed if we do not yet have a simple correlation between the deviation from the idealized dE/E spectrum and some group parameter such as $\Sigma_a/\xi\Sigma_s$? Following detailed thermal-spectrum calculations, who has tried to correlate a local flux dip with the magnitude of the absorption cross section in the vicinity? How much effort has been expended on correlating P_3 or other transport-theory results with the basic characteristic numbers of the unit cell? It is evident that no real attempt has been made to understand neutron behavior.

The reactor field has provided fertile ground for the growth of the machine philosophy. Most managers have little or no knowledge of analytical physics since reactors have been forced on industry almost overnight. When such a manager is told by his head physicist that $2-million of machine time are necessary to design a core, he has no alternative but to allot the money. And why quibble if the AEC will foot the bill anyhow? For years, engineers have been designing, on very limited budgets, machinery based on phenomena more complicated than neutron diffusion, such as turbulent flow by using simple correlations of complicated phenomena. Why cannot physicists base simple correlations on a small number of well chosen machine calculations?

To counteract the machine philosophy, I suggest that all machine results be treated as experimental data. Handled in this manner, the data will be plotted and cross-plotted, analyzed and re-analyzed, finally leading to simple correlations and insight.

—KARL H. PUECHL
Nuclear Materials and Equipment Corp.
Apollo, Pennsylvania

Georgia Tech Reactor

DEAR SIR:

In your tabulation of reactor builders on p. 19 of the January issue of NUCLEONICS, it would appear that Combustion Engineering has a construction contract for the Georgia Tech research reactor. Since we hope to invite bids on the project very soon, this entry in your table may prove to be discouraging to prospective bidders.

The facts are that General Nuclear Engineering Corp., now owned by Combustion Engineering, has the design responsibility for the reactor, and Robert and Co. Assoc., an Atlanta architect-engineer firm, has the design

responsibility for the reactor containment building and the supporting laboratories and offices.

We are somewhat behind schedule, but are hoping to receive bids for construction of the entire project by the end of March.

—W. B. HARRISON, Director
Reactor Project
Georgia Institute of Technology
Atlanta, Georgia

Navy Business for Numec

DEAR SIR:

Your January article on Numec (p. 20) was most gratifying. In at least one important respect, however, it was too generous to us in magnifying the difficulties that we have had to overcome. I believe some clarification would be appropriate.

I refer to the statement that ". . . Numec has been shut out of . . . [the naval reactor program] market . . ." It is true that during our first year of business, before we had established any record of production, there were problems in gaining acceptance as a qualified supplier for the naval program, as well as for other programs. This is a notable difficulty for new companies. Since that time, however, we have done a substantial volume of business with both Bettis and KAPL.

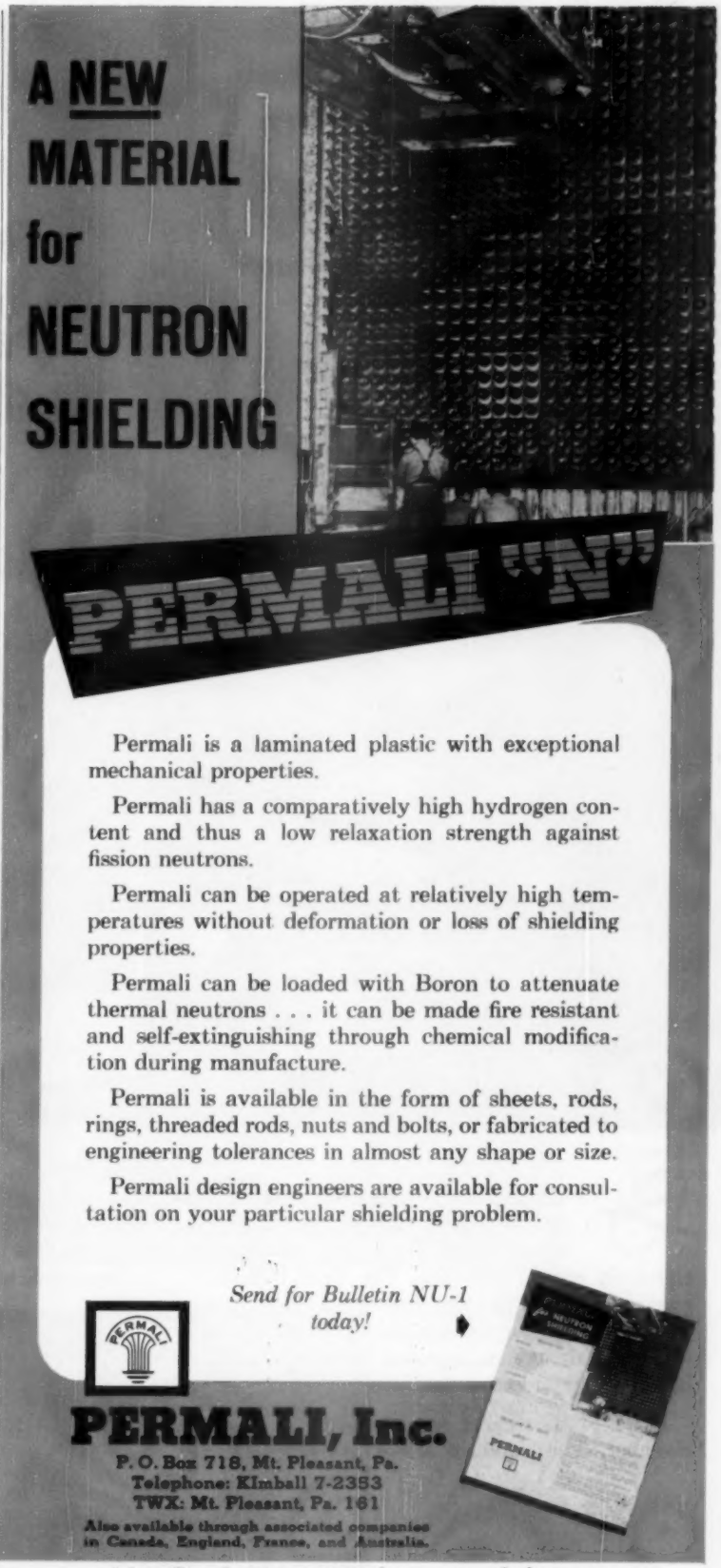
In the case of Bettis, we have, in addition to carrying out an important program involving chemical and spectrographic analytical services and providing tensile testing at elevated temperatures, supplied uranium compounds, burnable poison strips, niobium and Zircaloy powders, sintered ceramic UO_2 shapes, high-fired UO_2 spherical particles and UO_2 spheroids clad with various metallic coatings, such as niobium and chromium.

We have similarly provided KAPL with burnable poison strips, analytical services, reactive-metal powders and coated UO_2 particles.

In addition, the Commission has awarded us sizable contracts for the recovery of special nuclear material from scrap arising from the naval reactor program.

In all fairness, therefore, we would not wish your article to be construed as suggesting that we are presently being excluded from the naval reactor market. Any such inference would, obviously, be incorrect, and we would appreciate it if you would make this clear for the record.

—ZALMAN M. SHAPIRO, President
Nuclear Materials and Equipment Co.
Apollo, Pennsylvania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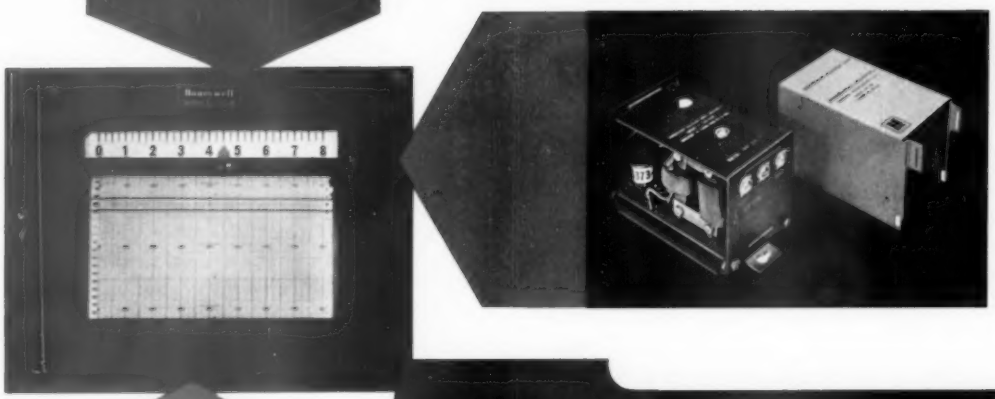
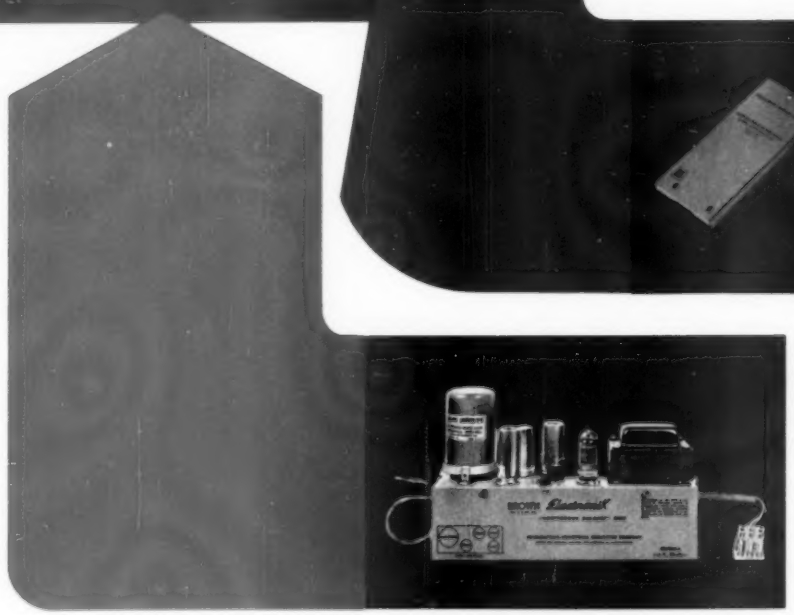


CONSTANT VOLTAGE UNIT* eliminates need for batteries, standard cells, and standardizing mechanisms . . . insuring long life.

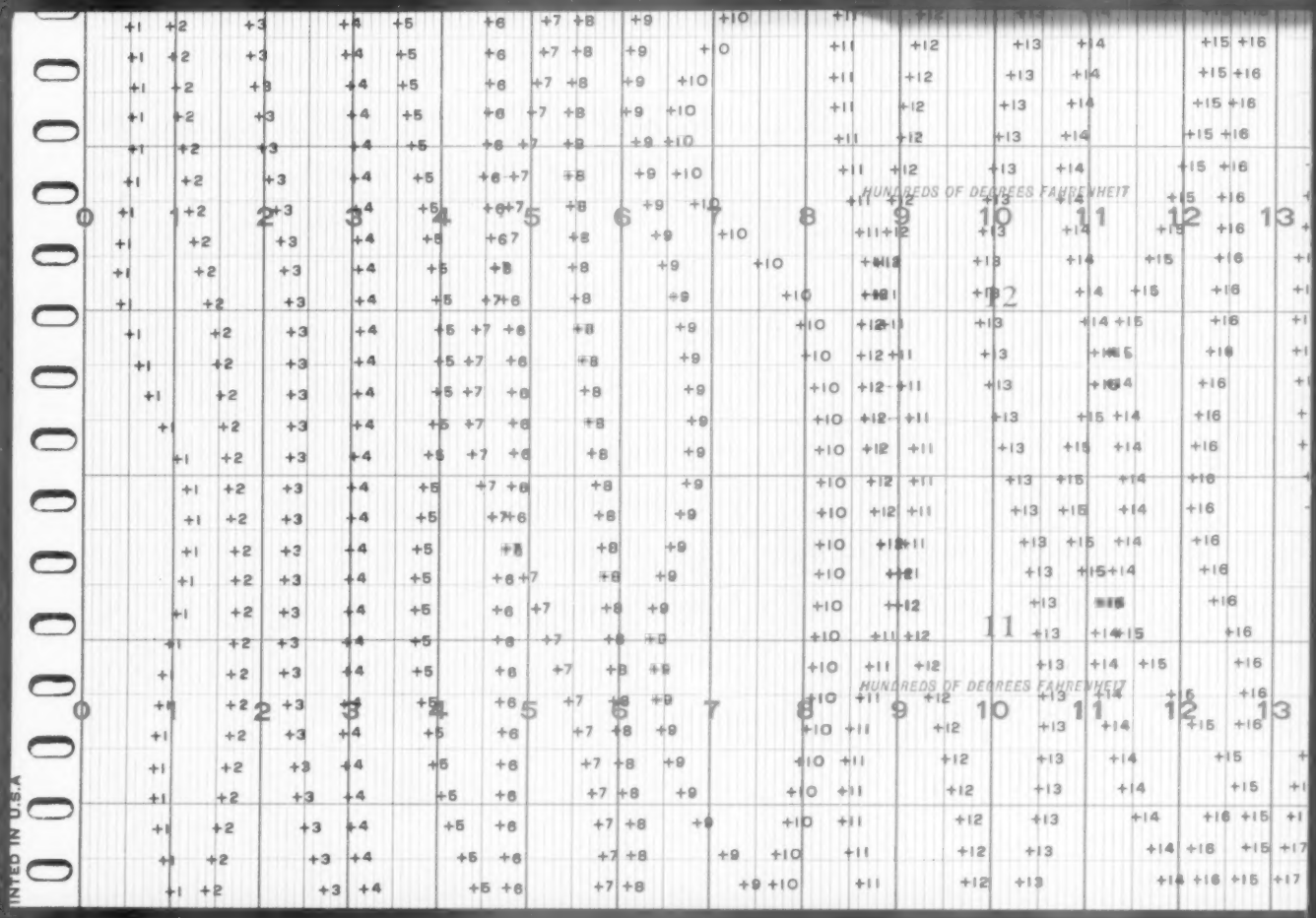
*Zener Diode

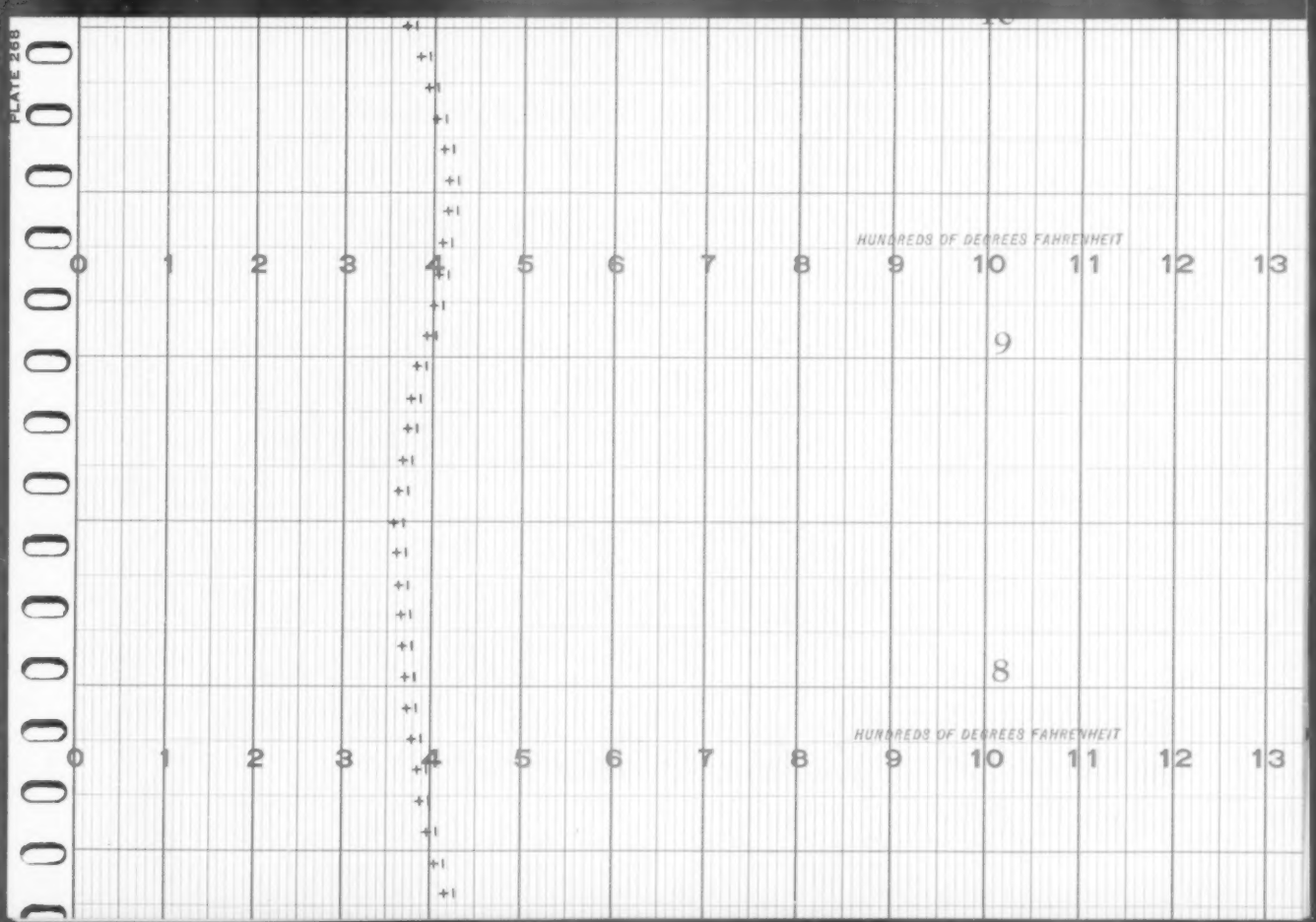
COMPARTMENTED MEASURING CIRCUIT UNIT makes range changing easy. Change one screw on a clip connected card of fixed resistors, and the job is done in a matter of seconds.



QUICK-CONNECT AMPLIFIER is easily removed from the instrument by means of a polarized plug.

BUT THIS IS JUST PART OF THE STORY OF THE 1960 LINE OF ELECTRONIK POTENTIOMETERS.
LOOK AT THE DRASTIC CHANGES IN THE ELECTRONIK MULTI-RECORD RECORDERS.





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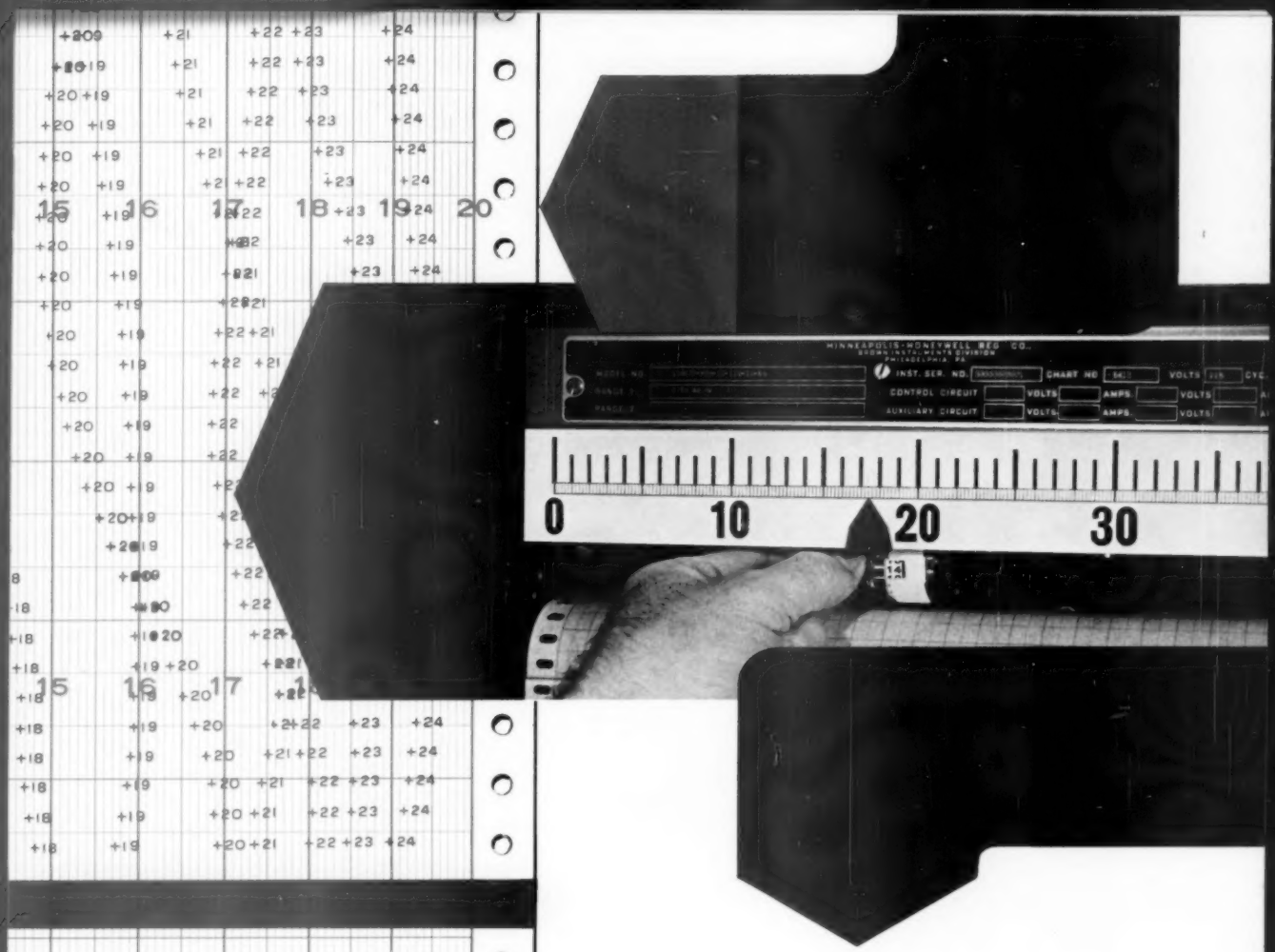

Record 2 to 24 points on one instrument with new UNIVERSAL *ElectroniK*

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Now, you can record 2,3,4,6,8,10,12,16,20, or 24 points on one ElectroniK Multi-Record Instrument . . . and change the number of points to be recorded in a matter of seconds. It's easy as this: remove a thumb-tight nut and slip off old print wheel . . . and indicator dial. Slip on a new wheel and dial: Replace nut. Plug in the number of points desired, and the job is done.

The universal features and modular design of the 1960 line of ElectroniK potentiometers are standard on all multi-record non-control models. Range and compensation changes are quick and easy, too . . . just change the cards.

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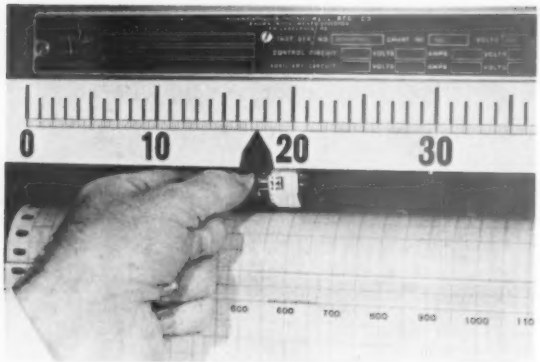
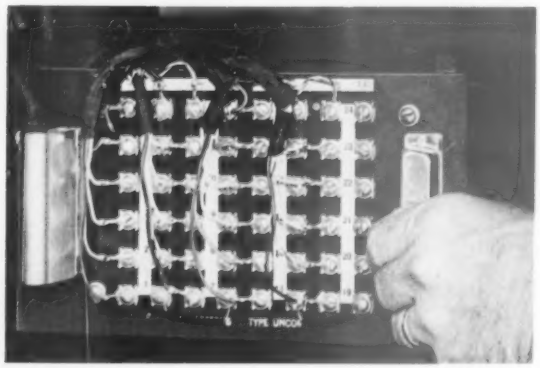
SEE HOW EASY THE 1960 ELECTRONIK MULTI-POINT RECORDERS ARE TO USE...

all it takes with the 1960 *ElectroniK* MULTI-RECORD RECORDERS to change . . .

. . . number of points recorded



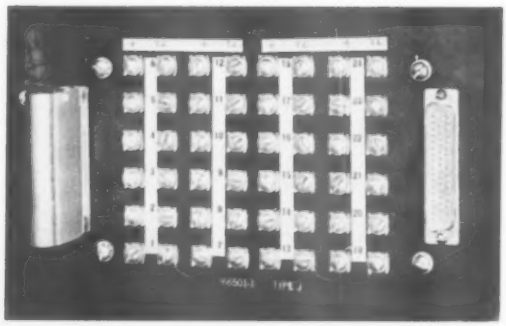
First: remove thumb-tight nut; slip off print wheel and indicator dial. Slip on new wheel and dial and replace nut.



Second: replace one plug-in unit and the instrument is ready to record a different number of points.

The new flexibility and convenience of the 1960 ElectroniK Multi-Record Recorders should interest you. This new design has resulted in substantial manufacturing cost reductions which are reflected in our new price structure. Your nearby Honeywell field engineer has the full details. He's as near as your telephone. Minneapolis-Honeywell, Wayne and Windrim Avenues, Philadelphia 44, Pa.

. . . RANGE—Loosen screws and slide out the range resistor card. Replace with a different card, tighten screws and the job is done quickly and easily.



. . . COMPENSATION—The input terminal board with built-in reference junction comes out by removing one plug. Slide in the new board, replace the screws and plug and the compensation is changed.

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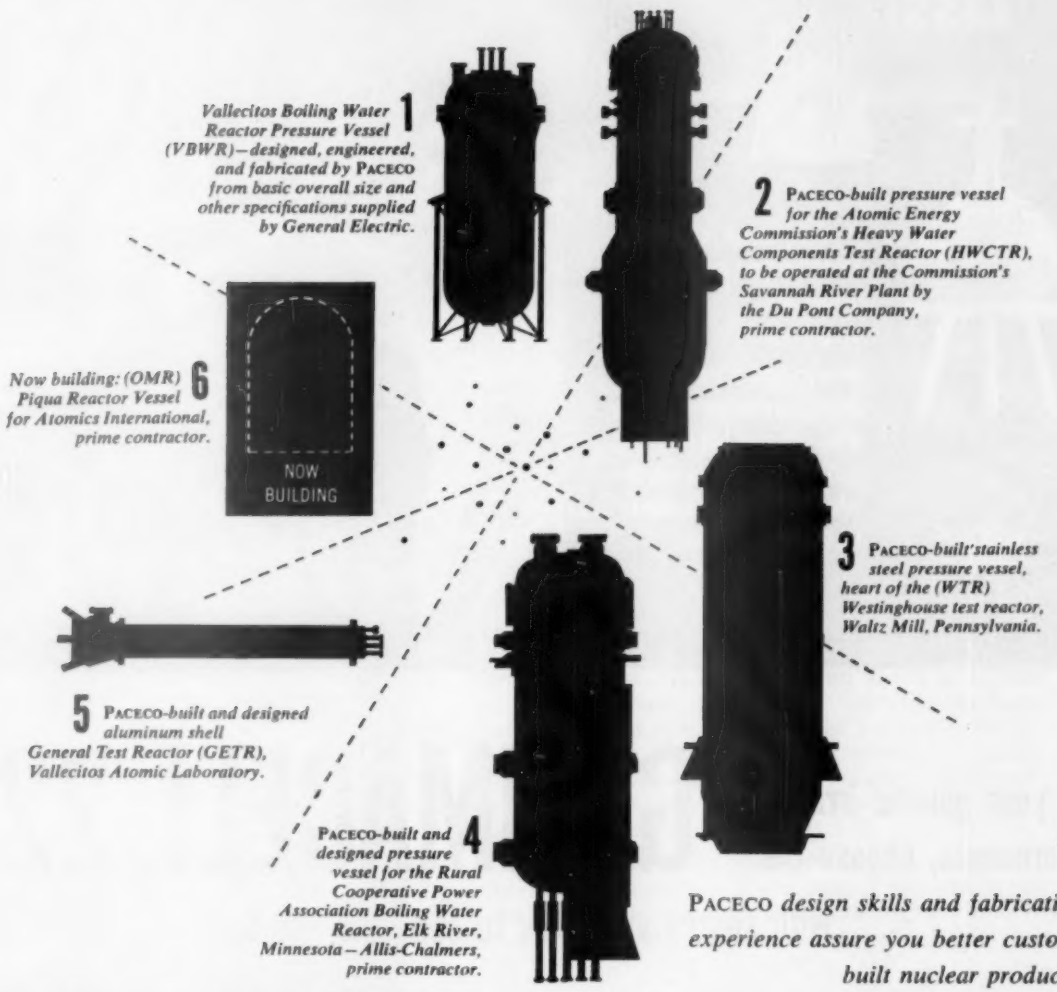

Vallecitos Boiling Water Reactor Pressure Vessel (VBWR)—designed, engineered, and fabricated by PACECO *from basic overall size and other specifications supplied by General Electric.* **1**

2 PACECO*-built pressure vessel for the Atomic Energy Commission's Heavy Water Components Test Reactor (HWCTR), to be operated at the Commission's Savannah River Plant by the Du Pont Company, prime contractor.*

Now building: (OMR) Piqua Reactor Vessel for Atomics International, prime contractor. **6**

3 PACECO*-built stainless steel pressure vessel, heart of the (WTR) Westinghouse test reactor, Waltz Mill, Pennsylvania.*

5 PACECO*-built and designed aluminum shell General Test Reactor (GETR), Vallecitos Atomic Laboratory.*

PACECO*-built and designed pressure vessel for the Rural Cooperative Power Association Boiling Water Reactor, Elk River, Minnesota—Allis-Chalmers, prime contractor.* **4**

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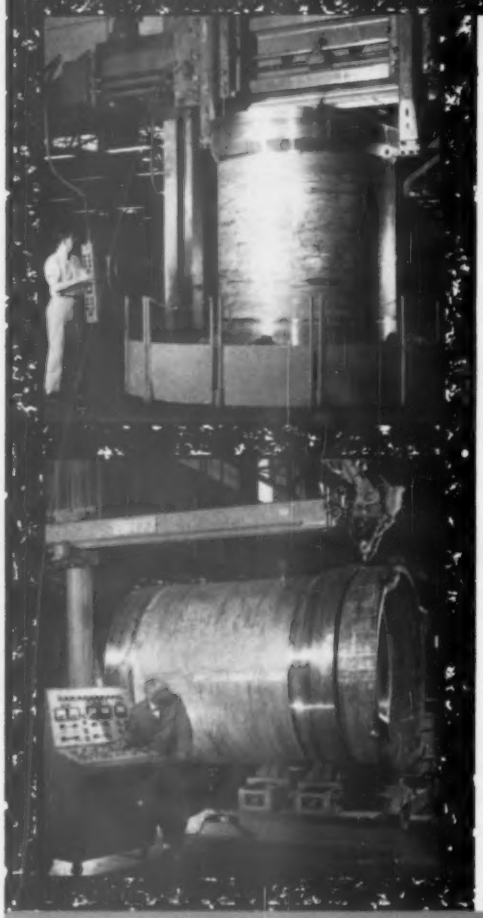

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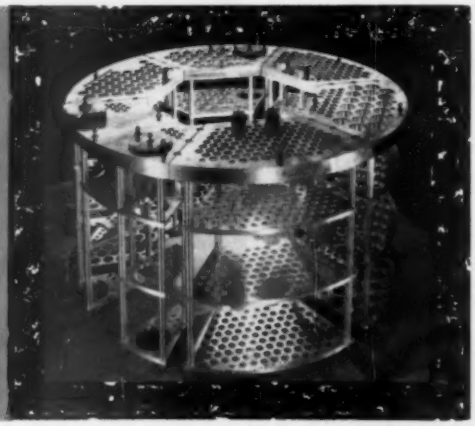

new nuclear plants choose

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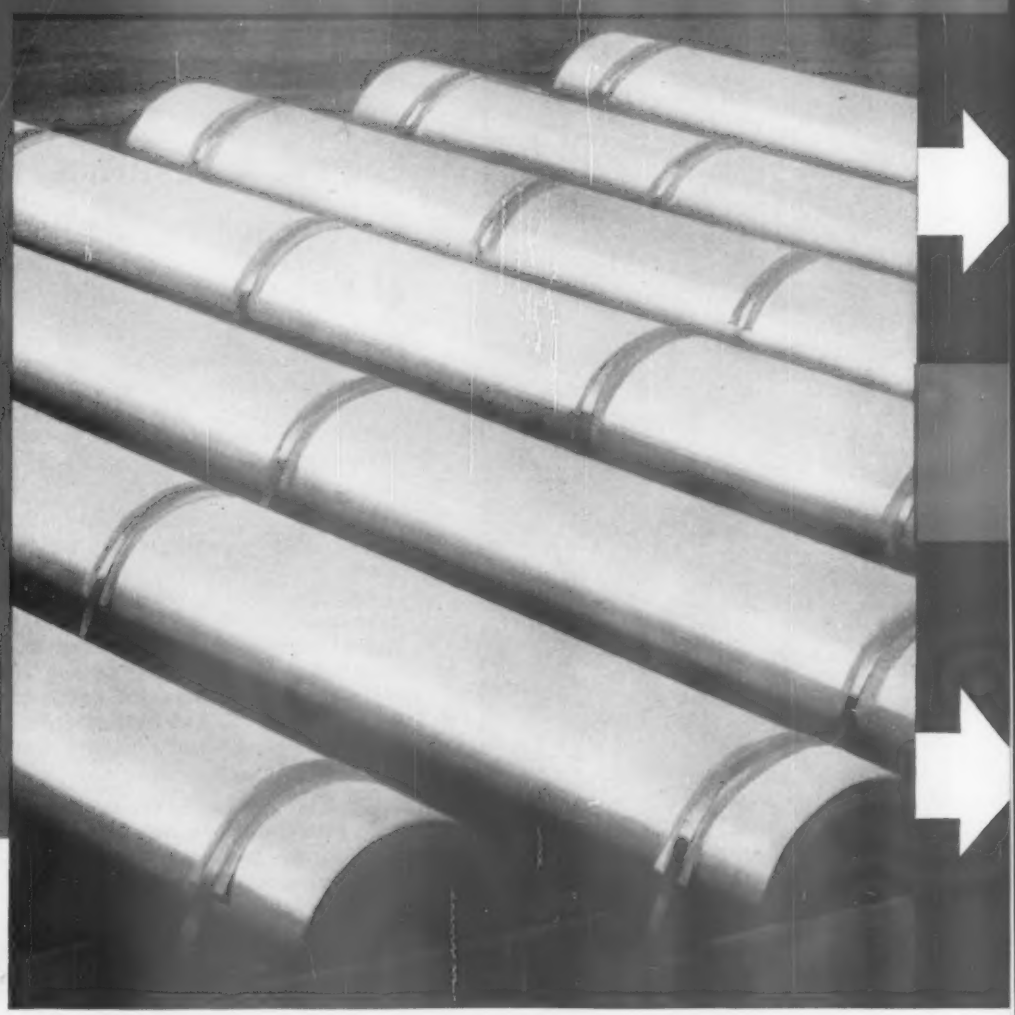

Centrifugal stainless steel castings readied for shipment by U.S. Pipe

The Government's new SPERT III nuclear plant at the National Reactor Station near Idaho Falls, Idaho, operating since December, 1958 to study nuclear reactor safety, uses U.S. Pipe's centrifugally cast stainless steel pipe for its coolant system.

SPERT III is classified as a high pressure, high temperature, light water moderated and cooled reactor. Its versatility permits transient tests under various initial conditions of pressure, temperature, and coolant flow. For example, pressures ranging from atmospheric to 2,500 psi and water temperatures from 68° to 668° F.

Another new nuclear power plant, engineered and constructed by Stone & Webster for Yankee Atomic Electric Company, is using centrifugally cast stainless steel heat exchanger shells made by U.S. Pipe and fabricated by the Southwestern Engineering Company in Los Angeles, Calif.

Stainless steel, centrifugally cast, made to rigid specifications, may be the answer to your piping or heat exchanger problem. For more information, write or call:

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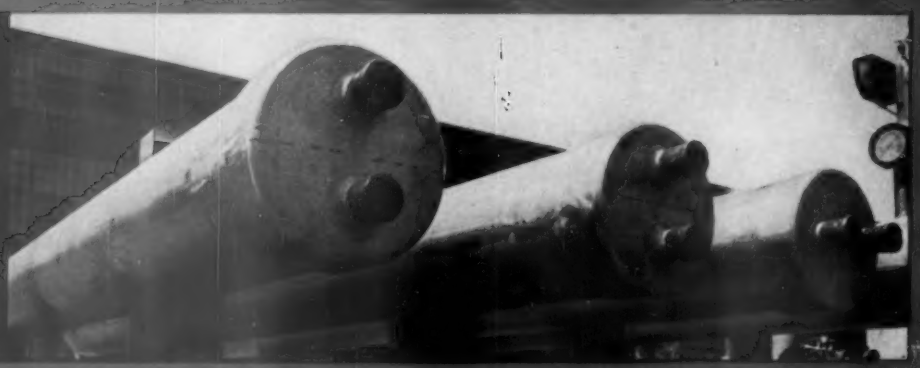
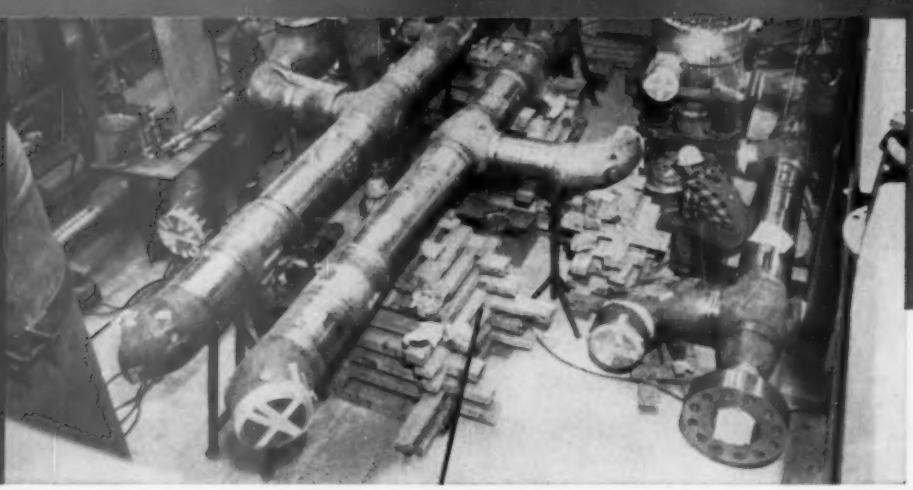
REQUIREMENTS OF NUCLEAR AND COOLANT SYSTEMS



Shop-fabricated heat exchanger shells of centrifugally cast stainless steel ready for shipment to the Yankee Atomic Electric plant at Rowe, Mass.

Subassemblies of primary coolant piping of centrifugally cast stainless steel being installed in SPERT III.



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CRITICAL FACILITY TANK at Greendale Laboratories measures 12 ft deep with a 9-ft diameter.

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has had a major stake
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for over 60 years

ALLIS-CHALMERS GREENDALE RESEARCH and development center for nuclear power includes the critical facility containing a full-scale mock-up of the Pathfinder reactor.

Trailblazer for Pathfinder

Full-scale critical facility speeds nuclear superheat calculations at Allis-Chalmers Greendale Laboratories

When this reactor at Allis-Chalmers nuclear test facility "went critical" *on schedule* late in 1959, a big step was taken toward successful completion of the world's first power reactor with integral nuclear superheat. The initial use of this valuable research tool will be for studies of the reactor core for Pathfinder. This controlled recirculation boiling water reactor is owned and will be operated by Northern States Power Co., Minneapolis, Minnesota.

This is just one of the major test facilities at Greendale Laboratories. Others include a steam separator test loop, complete facility for developing underwater handling techniques, a battery of corrosion loops, heat-transfer loops, water purification filter tests, and other experimental facilities.

These modern development facilities round out the comprehensive service Allis-Chalmers offers the nuclear power field. In addition to broad engineering and production capacity—plus more than a half-century's association with electrical power generation, transmission and distribution — Allis-Chalmers has a staff of specialists experienced in reactor design, construction, and operation. Here is a source of complete responsibility from investigation to start-up.

Ask for new facilities book 43B9541 — This 28-page brochure covers different reactor designs, laboratory and production capabilities. *See your Allis-Chalmers representative, or write Atomic Energy Division,* ***Allis-Chalmers,*** *Milwaukee 1, Wis.*

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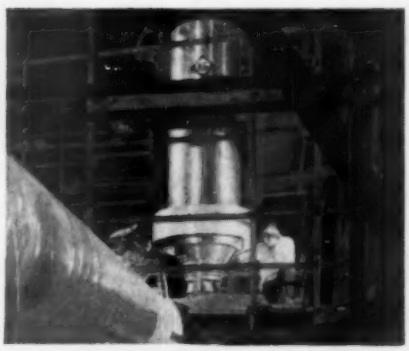

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In-pile capsule adaptation

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How will a gear lube or a cermet—or for that matter, any material—stand up in a nuclear reactor? There is only one way to be certain. Expose samples to the intense neutron and gamma fields present in an operating reactor. Keep accurate environmental records, and, in a special facility, subject the samples to complete analysis.

NDA has advanced the art of in-pile testing to a science. It organizes the testing program, adapts capsules and environmental recording instruments for the in-pile tests, and, after irradiation, analyzes the samples, by now highly radioactive. This examination is carried out in a special radioactive materials facility of NDA-Pawling Laboratories. NDA has conducted a large number of complete in-pile tests, and its established procedures are quickly and economically adapted to new programs.

The need to know is imperative when a material is destined for use in a reactor. Firms interested in adding the growing reactor market to their customer list are invited to discuss a suitable in-pile testing program for their products.

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Survey of 30 Utilities Shows 'Wait and See' Attitude . . .

The majority of the nation's utility leaders are participating—with cash as well as man-hours—in research-development programs to reduce the cost of nuclear power, but do not see an atomic plant in their own company's future for quite a few years ahead. A NUCLEONICS survey of the presidents of thirty of the biggest electricity generating companies turned up more pessimists than optimists on the nuclear power outlook. Among the optimists are two California utilities.

The utility leaders' replies in themselves plot the power-cost map of the U. S. with a nice degree of accuracy. Biggest pessimists are to be found in the coal-rich Ohio valley, the natural-gas fields of Texas, and the hydro-abundant Pacific Northwest. Most hopeful about nuclear power are utility executives in California, the Deep South and the Northeast.

The only definite long-term plans not previously known for installation of nuclear generating capacity were those of the Southern Company, Atlanta, and Southern California Edison (*see below*). Southern's system expects to have at least one nuclear plant, probably one of about 150 Mwe, under construction shortly after 1965 and in service by 1970, according to President Harllee Branch Jr.

"On the basis of competitive fuel and construction costs, our experts believe that we probably would not be justified in undertaking the design and construction of a nuclear plant before 1965," Branch says. "We expect that as conventional fuels become more expensive—and we do think they will become more expensive and less available for power generation—utilization of nuclear energy for power purposes will be accelerated.

"Probably by 1980 we will have about 1,400,000 kw of nuclear capacity on the Southern Company system."

The system's associated service company, Southern Services Inc., at Birmingham, Ala., has set up an atomic power section; it is headed by Ruble A. Thomas, who has spent the last five years in nuclear power research for the company.

Utilities Already Building

California's apostle of rapid nuclearization of generating capacity, President Norman R. Sutherland of Pacific Gas & Electric Co., says competitive nuclear power will be available in California by 1962.

"Nuclear power is an eventual must for the industry," he says, and meanwhile the role of the utility is "to keep abreast of scientific and technical advances, to participate in such advances as far as possible" to expedite construction of nuclear plants.

"Operating the Humboldt Bay plant all by ourselves will certainly put us in good shape to operate a bigger one later," the PG&E executive says.

"It is only through repetitive construction that capital costs can be lowered—and present costs must be brought down on a wide front."

Sutherland told NUCLEONICS as recently as Jan. 5 that he felt $300/kw capital cost for a nuclear plant is "almost possible" today, and can be reduced in a few years to $250/kw. Only a month later he had offers from two manufacturers for $213/kw nuclear plants. Fuel fabrication cost is expected to be cut by ⅓ and fuel life prolonged by ½, and PG&E feels that where conventional fuel cost is above 40¢/million Btu and hydro is not available, nuclear energy at $300/kw or less is the most economical method of supplying power for plant factors above 75%.

Only a minority of Sutherland's colleagues, however, share his views (or his favorable economic circumstances) for repeat orders. Officials of the earliest-pioneering utilities—Consolidated Edison, Commonwealth Edison, Detroit Edison, Duquesne Light—have said privately that they wouldn't be investing as heavily as they are in nuclear power if they planned to build only one nuclear plant and then forget about atomic energy. But prior to PG&E, only one utility had publicly announced plans for a second reactor before

. . . But Two Coast Utilities Weigh Huge Reactors

Pacific Gas & Electric and Southern California Edison were moving last month toward separate decisions on whether to add huge nuclear plants to their grids. Westinghouse and General Electric—once again—are down to the wire bidding for the business. Spurring the utilities on was AEC, anxious to have an early announcement from at least one.

Norman Sutherland, PG&E president, told NUCLEONICS that GE was offering a three-reactor station of 300 Mwe gross, 288 net, using boiling-water natural-circulation units. Westinghouse, he said, was offering its basic 330-Mwe closed-cycle reactor (NU, Oct. '59, 17), upgraded to 360 Mwe gross, 340 net. This plant, he said, comes out at about $213/kw installed; the "three-pot plant" by GE "stacks up about the same on capital cost."

Both Westinghouse and GE were proposing in collaboration with Bechtel Corp. as architect-engineer. But Sutherland, whose company has a very active engineering department that likes to do its own work, said: "We might put it together ourselves."

Westinghouse and GE were understood to be making similar proposals to Southern Cal Ed.

Sutherland indicated PG&E was trying to make a decision by late February. Anticipating an announcement from the Coast, AEC Chairman McCone and Congressional leaders have discussed possible federal aid beyond the usual fuel-charge waiver but Sutherland said his company was not interested.

completing its first: the New England Electric System (NU, Dec. '56, R3). However New England is not expected to move until the Yankee reactor has been completed and early results have been evaluated.

Commonwealth of Chicago, which has room at Dresden for several power plants, has been investigating various possibilities for Dresden No. 2 for some time (NU, Oct. '59, 23). The utility reportedly was approaching a decision to undertake a project when the control-rod and cladding-tube-crack "bugs" appeared in Dresden No. 1 (NU, Jan. '60, 18). It has now decided to await Dresden results.

The Waiting Game

In so doing, it is joining a considerable number of utilities seated on the fence watching the first-generation plant builders. For example Union Electric of St. Louis, Mo.—one of the first four utilities in the country to enter the atomic energy field back in June 1951—now says, "We are participating in the Dresden plant [as a member of the Nuclear Power Group] and until that is finished we are not making any specific plans." Likewise the newest utility combine formed, the New York State group ESUPRA (Empire State Utilities Power Resources Assn.), contains strong voices urging waiting for Indian Point results, although no decision has yet been made.

This tendency would seem to indicate that the period 1961–62, when the first generation plants (Dresden, Yankee, Indian Point, Fermi, Elk River, Piqua) start yielding meaningful results—not so much as fissioners of nuclei but rather as commercial machinery for electricity generation—will be a period of heightened activity in reactor sales.

But in the citadels of low-cost fossil fuel, utilities today are tempering their dedication to close surveillance of, and research participation in, atomic energy with a much longer view of the time when they might add nuclear capacity to their own grids. The phrases "5 to 10 years" and "10 to 15 years" crop up. Here are some comments by utility leaders in NUCLEONICS' informal survey:

• **Wisconsin Electric Power Co.,** Milwaukee: "We must keep in close touch with the advances made in the production of nuclear power and be prepared to utilize it when it appears appropriate to do so. . . . Our company, as a member of APDA and PRDC, is contributing toward the development of nuclear power. . . . It is obvious that this work has to be done before large-scale use of atomic power can be undertaken with confidence. . . . When nuclear power passes the test of suitability and competitive costs for our system, we will give it serious consideration. With the abundance of reasonably-priced coal available to our electric power plants in Wisconsin, there is no developed nuclear power plant of this size capable of approaching over-all costs of operation of our steam plants now under construction, and there is no current evidence which pinpoints just how many years in the future it will take for nuclear power to become commercially competitive in southeastern Wisconsin."

• **San Diego Gas & Electric Co.:** "In view of our size we wouldn't step out and build a nuclear plant until its cost of operation has proved competitive with conventional plants. It is our feeling that as time goes on and costs come together, we will be more interested—perhaps in five or ten years. . . . We have set aside $100,000 yearly for research-development in the nuclear power field [as a member of HTRDA] through 1963."

• **Seattle City Light:** "Plans for increasing hydro production facilities, including long-term power purchasing contracts now in force, will give us cheaper power than anything we can see in the atomic energy field in the next ten years. Our present power production costs are just under 3 mills/kwh."

• **Pacific Power & Light Co.:** "We are in about the same position we were in a year ago. We know there is great promise in nuclear power. We know it works physically, but we have yet to see any nuclear plant that can develop economic power in terms of what we can still develop from both hydro and fuel. In the Northwest we still have much undeveloped hydro; there are vast coal resources in Wyoming. We may find in the Northwest that some fuel plants using local low-grade coals can be cheaper than nuclear plants. Nuclear power has now become physically available so it's not a curiosity, but it hasn't reached the economic thresholds we in the Northwest require. It doesn't look as though it will for at least a decade. We may be in the third generation of nuclear plants before it does. PP&L is taking a very serious, continuous look at the possibilities, however [as member of the HTRDA and Rocky Mountain groups]." Average power cost in PP&L's area: 3.2 mills/kwh.

• **Portland General Electric Co.:** "Our primary interest is to keep abreast as well as we can of developments in the nuclear power field. We expect it to be some time before nuclear power will be economically competitive in this region. If we can proceed to develop the remaining hydro plants and the more economical steam plants, we're looking perhaps 15 years into the future."

• **Montana Power Co.:** "Because of the hydroelectric and conventional fuel resources in Montana, the company's studies have led it to the conclusion that nuclear electric power will not be competitive in this area for the long-term future unless very

Britain planning big fast-breeder power plant

London will soon announce a huge new fast breeder, intended as a prototype for commercial power plants, NUCLEONICS has learned. The 800-Mwth, 200–300-Mwe unit would have a more flexible fuel and heat-removal system than the 15-Mwe experimental breeder at Dounreay, but no details are yet available (as a matter of fact, the Atomic Energy Authority is reportedly unhappy that AEC Chairman McCone talked about the project, not yet officially disclosed, before the Joint Committee). A critical experiment for it—Zebra (Zero Energy Breeder Reactor Assembly)—is planned.

AEC denies competing with industry; AIF asks clarification

In a reply to three industrial groups that had complained of unfair competition, AEC asserted it has never engaged in activities that could normally be performed commercially. And it promised the National Association of Manufacturers, the U. S. Chamber of Commerce and the Manufacturing Chemists' Assn. that it will not compete with private industry. Simultaneously the Atomic Industrial Forum asked AEC for clarification of its intentions and a committee to study the problem (*see p. 31*).

major advances are made in reduction of the cost of nuclear power. For that reason the company does not plan to develop nuclear power plants. It is continuing to follow closely the research and development in this field, and it is participating in the program of HTRDA."

• **Cleveland Electric Illuminating Co.** has spent $1.6-million on nuclear research projects, as member of HTRDA, APDA, and East Central Nuclear Group. But it does not look for nuclear-fueled generating plants to be put on the line in Ohio by investor-owned utilities for another 10–15 years. Best estimates now indicate nuclear power would cost at least twice as much per kw. "CEI's attitude can in no way be described as sitting on the sideline waiting for something to happen. The company has been in pursuit of the competitive atom for power too long—eight years—for any such interpretation. And its program, like that of the industry as a whole, keeps growing. But the company feels that nuclear power generating plant technology is not yet sufficiently advanced, nor are critical economic points adequately resolved, to justify laying definite plans to construct a nuclear plant of its own." Fossil fuel costs in Ohio range from 16¢/million Btu on the Ohio river to 26–30¢ in the north.

• **"Toledo Edison Co.** is participating in research-development projects of prototype nuclear power plants such as the Fermi fast breeder. However nuclear plants are not yet economically competitive in this area. Our information indicates nuclear power would cost our company a little more than twice present costs with conventional generating equipment. Thus nuclear-fueled generating plant technology and economics have still not arrived at the point where we can give serious consideration to construction of such a plant in the immediate future."

• **"Ohio Edison Co. and Pennsylvania Power Co.** are members of ECNG. This exploration of a new type of reactor (heavy-water, gas-cooled) is in keeping with the investor-owned utilities approach to orderly research, development and construction of a number of promising types and variations of experimental or small prototype reactors to determine which type or types will ultimately prove most advantageous. It is our opinion that this approach to the problem will achieve optimum progress and hasten the day when atomic power will become truly economical in this area."

Navy Fights Pt. Loma site; Allis-Chalmers gets reactor

The Navy has protested the AEC–Interior dept. proposal to build a low temperature, process-heat reactor for desalinizing seawater at Pt. Loma on the California coast (NU, Feb. '60, 18). At that location, the Navy says, the reactor would present a safety hazard, according to Interior dept. officials. Reactor contract for the ELPHR (Experimental Low-temperature Process Heat Reactor) has been awarded by AEC to Allis-Chalmers and the project is ready to go ahead on an 18-month construction schedule. However, Navy must first transfer the Pt. Loma site to Interior. The issue is now in the hands of the Cabinet; if it should decide for the Navy, Interior says it has other sites that might be suitable.

HRE-2 has second hole; both to be fixed for 2-region operation

A second hole has been burned in the wall of the inner core tank of Oak Ridge's Homogeneous Reactor Experiment No. 2, it was discovered after the unit's recent 105-day continuous run. HRE-2 was shut down Jan. 23 to investigate a change in fuel concentration in the inner core and outer blanket regions, and inspection disclosed a 1½ × ½-in. hole just below the inner tank's equator and about 90 degrees around from the first 1½ × 1-in. hole that occurred two years ago (photo, NU, Feb. '59, 26).

Like the first one, the new hole is believed to have been caused by flow conditions that permitted fuel concentration forming hot spots on the tank wall surface. A method of repairing the first hole was sidetracked to permit operation of the reactor for studies of fuel-solution stability; it performed well for the last 18 months essentially as a single-region reactor. It is now planned to repair both holes (a 4-month job) and to resume operation as a two-region unit with flow reversed (from top to bottom) to end hot spots.

AEC proposes $171-million '61 construction program

AEC's authorization bill for plant and equipment spending in fiscal year '61—$171-million total—was presented for Congressional approval last month (*related story page* 25). It includes: $24-million for a high-flux test reactor (provisional on offering industry a chance to build it); $5-million for a joint research-development program with Canada on heavy water; $20-million for a nuclear-rocket test installation at Los Alamos; a boost from $5- to $9-million for a 150–175-Mwe core for Shippingport (power over 100 Mwe would go to a heat sink unless Duquesne Light agrees to provide generators); $15-million for new unsolicited proposals under the civilian reactor program; and $25-million for construction of a 50-Mwe organic prototype if no reasonable industry proposal is forthcoming (NU, Feb. '60, 17); if cooperative construction with industry is worked out, the funds would be used for either a spectral-shift, pressurized-water prototype or a small military reactor overseas.

Two food-irradiation programs get up steam

Army Research and Development Chief Richard Morse has approved a new food-irradiation facility (1-million curie cobalt-60 source and linear accelerator—both for research only) for the Quartermaster Corps. Meanwhile, an interdepartmental committee on food irradiation endorsed a civilian food-irradiation program under direction of AEC. Funds for an irradiator to fit into this program may be requested by AEC this year.

Harmony Reigns in Capital as AEC Unveils Program . . .

1. Another year of peace in the civilian atomic power debate appears to be assured in Washington.

2. But the prevailing harmony has almost totally submerged the militant attitude of Congressional Democrats, which, in prior years, had served significantly to boost total AEC spending on civilian reactor development.

3. The harmony may have its roots as much in the lack of a crying need for new reactor projects as in the excellent relations between AEC Chairman John A. McCone and the Democratic leadership of the Joint Committee on Atomic Energy.

This was the situation in the capital last month when the McCone Commission went up to Capitol Hill to present: 1. its long-range program for achieving competitive nuclear power before the end of the decade; and 2. its construction program for fiscal 1961, which begins July 1 (*opposite page and page 23*).

Even before AEC's program presentation, Joint Committee leaders were indicating that they were not in a militant mood on civilian reactors. There were a few things they were unhappy about but these were outside the heretofore explosive civilian-reactor area: chiefly, the nuclear rocket, where the fiscal '61 budget has been cut by $16-million to a total of $39-million; the sharply slashed food-irradiation program (NU, Feb. '60, 21); and the burgeoning exchange arrangement between the U. S. and the USSR.

ANDERSON AND HOLIFIELD

In telephone interviews, JCAE Chairman Clinton P. Anderson (D-N. M.) and his heir-apparent next year, Rep. Chet Holifield (D-Cal.), expressed their views on a number of major issues.

Relations with AEC. Both made it clear that they hold AEC Chairman McCone in high regard and respect his budget problems. It is equally clear that many of the major nuclear policy decisions in Washington are being made in a series of talks between Anderson and McCone, subject to whatever checking back is necessary with their respective colleagues.

"In fairness to Mr. McCone," said Holifield, "I would be happy to state that he has been fair with the Committee in his presentations. There has been no personal difficulty between McCone and the Committee. We feel he has acted in good faith.

"But we feel that, as a representative of the Administration, he is under budgetary restrictions."

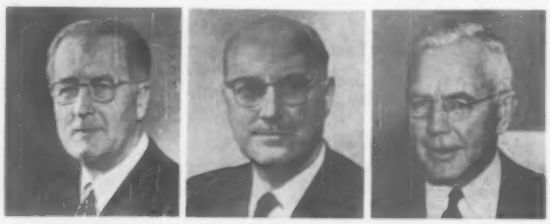
Civilian Reactor Program. Anderson said he wanted to wait for AEC's program presentation before he attempted to appraise it. He said he had had indications, however, that the program would be a "good" one. "We are not going to be very enthusiastic," he added, "about cutting down to 3–4 concepts." (NU, Jan. '60, 17).

Holifield said the Administration was "very much against what I would call an aggressive program" so he was suggesting a "practical and attainable" program for fiscal '61—authorization of a heavy-water, natural-uranium prototype; a steam-cooled prototype; a 20-Mwe military reactor for Guam; and conversion of the new production reactor under construction at Hanford to production of electricity (700 Mw), as well as plutonium. He also said he was hoping for financial aid, if necessary, to two large reactors under consideration in California (*see page 21*).

"In view of the opposition of the President and the Budget Bureau," he explained, "I realize an aggressive program cannot be legislated this year and that any aggressive program would be vetoed by the President."

Shippingport. Anderson and Holifield said they would look favorably on a proposal that AEC reduce its price for steam to Duquesne Light Co.—steam from the proposed second core at Shippingport—if Duquesne agrees to provide the extra generating equipment to take the reactor to 150–175 Mwe. In stalemated negotiations with AEC, Duquesne has said it cannot deal with the government unless it gets cheaper power than it is now getting (8 mills/kwh now) and long-term guarantee of steam supply.

U.S.-Soviet Agreement. Both Congressmen look warily on the U. S.-Soviet arrangement to exchange scientists and information (NU, Dec. '59, 24). Anderson said he was particularly unenthusiastic when he contemplated negotiations at the "second-team" level; that is, at staff levels below McCone and Soviet atom chief Vasily Emelyanov. He said the Russians must be made to demonstrate that 1. they are declassifying appropriate exchange data and 2. that they are willing to give as well as take.



Anderson Holifield McCone

Chairman McCone was in a fighting mood on the U. S. reactor program when interviewed in his downtown Washington office. Not only had he been getting the usual criticism that the program was not aggressive enough but complaints, as well, that it was too aggressive. Just a few days earlier, former AEC Chairman David Lilienthal had attacked the program as not worth the effort going into it. Calling for a federal effort on something more critical than nuclear power (development of water resources), he declared: "By and large, the [nuclear power] program has been quite a flop and is not to be taken seriously."

Obviously impatient with his critics but refusing to reply directly to any one of them, McCone unwound:

"It is my belief that the development of competitive nuclear power has been more difficult and more costly and presented more forbidding technical problems than was expected. And difficult things take time; impossible things take a little longer.

"We are going to pursue the development of nuclear power energetically and we are going to break down these obstacles. We are going to develop methods of producing competitive nuclear power in large areas of the U. S. in a relatively few years. . . .

"We have to look—in the interests of the U. S.—a long way ahead because conventional fuels are not going to be available forever. I am sorry that it's a tough problem but we're going to answer this problem."

Shippingport. McCone said he "would like very much" to see the pressurized-water reactor at Shipping-

port go to 150-Mwe with generating equipment supplied by Duquesne. The generator now on the site has a 100-Mwe rating and cost of additional capacity has been estimated at between $15- and $23-million. Duquesne has explained to AEC that these funds must buy power at the going rate for conventional plants and, moreover, there must be a long-term commitment for steady power supply.

"It's a difficult negotiation," McCone commented, "because an agreement equitable to both Duquesne and the government must be reached. Whether that can be done right now I don't know."

The alternative, he explained, was the dumping of power over 100 Mwe to a heat sink. While this was a possibility, he said, AEC would much prefer to go to full-scale electrical production. "Upsizing the same plant from 60 Mwe to 150–175 Mwe is very significant," McCone pointed out.

"I intend to exhaust every means to find a way to [expand] this as a power plant," he concluded.

. . . The 10 Year Plan Re-Affirms '68 Economic Power Goal

An historic series of papers—AEC's 10-year civilian power program and three back-up documents—was presented to the Joint Committee on Atomic Energy last month by AEC Chairman John McCone.

The program's major elements are not new: competitive nuclear power by 1968; early emphasis on advanced concepts to meet this goal; and an AEC commitment to build specific experimental and prototype reactors when industry support fails to develop. Disclosed for the first time were:

- AEC's program for taking eight reactor concepts to economic status and AEC's estimate as to when this might occur for each concept. However, not one of the 12–14 new developmental reactors mentioned in the paper is positively scheduled for construction.
- AEC's belief that no more than two new developmental reactors should be initiated during the next two years: a possible homogeneous experiment No. 3 and a 50–100-Mwe, spectral-shift, pressurized-water prototype (mixing light and heavy water).
- AEC's estimate that the program, in its early years, would cost an estimated $180–200-million annually, the bulk of it government money.

Paradoxically, while the program defines the 1968 goal as the date when utilities can order large-size reactors for economic reasons (high-cost areas), the assertion is made that this can be done *now* for big boiling- and pressurized-water reactors (*see page 21*). AEC's concept-by-concept analysis of the years ahead:

1. Pressurized-water. A prototype based on experience at Shippingport, Yankee and Indian Point will "probably" be justified for construction start in '63 or '64. Also, a spectral-shift prototype may be scheduled in the early '60's. Estimate of 1960–70 spending on the PWR concept, including Shippingport, $280-million.

2. Boiling water. In '63 or '64 AEC will determine, based on experience to that date "what, if any, additional experimental or prototype reactors are needed." AEC will also determine then whether a 20–30-Mwe prototype should be scheduled for the small-reactor field. BWR spending 1960–70: $195-million.

3. Nuclear Superheat. If justified, a 100-Mwe prototype "probably would be initiated in 1963." By 1968–69, a 300-Mwe reactor may be economic in high cost areas. The BWR estimate above includes superheat.

4. Organic. By the mid-1960's a 50–100-Mwe prototype may be justified. In any case, organic reactors should be competitive by '65 or '66 in 300-Mwe sizes. 1960–70 spending: $175-million.

5. Sodium, fast and thermal. Sodium reactors likely to be competitive in late '60's or early '70's. Also likely that AEC's next prototype would be a 100-Mwe fast or epithermal reactor, for construction start in '63 or '64. AEC noted that sodium-cooled fast reactors offer all the advantages of sodium-cooled thermal reactors, plus breeding. However, a thermal experiment or prototype may be considered for '63 or '64. Spending 1960–70: $570-million.

6. Gas-cooled. Next prototype—a 100-Mwe unit—could be considered in the mid-1960's—a choice between the approaches exemplified by the Experimental Gas-cooled Reactor at Oak Ridge and the High-temperature Gas Reactor to be built at Peach Bottom, Pa. Gas reactors will not be economic until the early '70's. 1960–70 spending: $228-million.

7. Heavy water. No new construction before '66 or '67. Spending 1960–70: $283-million.

8. Aqueous homogeneous. In '62 or '63 a third experimental reactor might be scheduled—which "should demonstrate breeding, or, as a minimum, a high conversion ratio." If HRE-3 is successful, a 50-Mwe prototype could be initiated in the late '60's. 1960–70 spending: $178-million.

Beyond the programs for these specific concepts, the "white paper" envisages: possible construction of 3–5 new-concept experiments (of the "cheap and dirty" type like the Organic Moderated Reactor Experiment); $322-million for general reactor-engineering work, 1960–70; $102-million for reactor safety; and $94-million for recycle of plutonium.

Other Highlights of McCone's Testimony at '202' Hearings

- **Nuclear Business Level.** Reactor projects under construction or active development as of Sept. 30, 1959, represent $1.7-billion (not including projects completed as of then); the bulk of this remains to be spent. $1-billion represents civilian projects. $700-million military—two-thirds of that naval. The figures are conservative, excluding aircraft propulsion, critical experiments, training reactors, and general research-development.
- **Isotope Processing.** AEC will provide 100,000 curies cobalt-60 to the Bureau of Mines for a research-development facility for beneficiation of coal and metals via radiation (NU, Jan. '60, 27).
- **Reactor site criteria.** A proposed regulation on site criteria has been temporarily shelved pending study by a special working group. Members: Miles Leverett, General Electric; Warren Nyer, Phillips Petroleum; Bernard Spinrad, Argonne; James Sterner, Eastman Kodak; T. J. Thompson, MIT; Hood Worthington, du Pont, and Clifford Beck, AEC.
- **Regulations.** AEC has taken steps to 1. clarify and simplify regulatory procedures; 2. refine health and safety standards, particularly those relating to reactors; 3. transfer inspection of all AEC licensees from the Inspection Div. to a new Compliance Div. under W. F. Finan, assistant general manager for regulation and safety. Proposed new rules are also coming on isotope radiography and shipment of irradiated fuel.

British Program May be Cut Back; Companies Realigning

A cutback in Britain's civilian nuclear power program, from 6,000 by 1966 to perhaps 3–4,000 Mwe is now imminent, NUCLEONICS learned in London.

The reason to be given by the Atomic Energy Authority will be the current coal surplus—and certainly political pressure against "subsidizing atomic energy" may be expected to build up; it will be maintained that the cut does not in any way stem from technical reasons.

At the same time it seems clear that the Advanced Gas Reactor development program is not maintaining schedule. AEA has reaffirmed beryllium as ultimate cladding material for the AGR pilot plant at Windscale (NU, Jan. '60, 23), but the first core will use some beryllium-clad and some stainless-steel-clad elements "to gain experience," Sir William Cook, AEA member for development and engineering, disclosed in Philadelphia last month.

The evident fact that beryllium will not be ready in time for an entire core-loading is being interpreted in England as necessitating a stretch-out or postponement of design development work on Oldbury Power Station, slated to be the first commercial scale-up of the AGR concept. Government and industry sources now feel Oldbury—sixth of the Central Electricity Generating Board's stations in England (not counting Hunterston being built by the South of Scotland Electricity Board)—is likely to be the last atomic station built, for the present at least.

Yet the fact that CEGB has not applied for further sites does not in itself mean the Board couldn't meet its original larger capacity goal. The sites at Bradwell, Berkeley, Hinkley Point, Dungeness and Sizewell have each been prepared for a second station, and can satisfy the cooling-water requirement. (The water systems at Hinkley Point have already been laid for a double station, NUCLEONICS understands.) But at least one source feels there is little likelihood of the second stations' materializing.

As for the planned switch from the Calder-type using magnox cladding to the AGR-type; (which it had been contemplated would take place between Sizewell and Oldbury) one key British industrial figure told NUCLEONICS that Sizewell would not be the last nuclear power station in Britain of the Calder series using magnox cladding. He predicted that Oldbury, if built to the AGR design, would not be the next station to be built after Sizewell; or if next to be built, will use magnox-clad fuel. In fact there may never be a commercial-size scale-up of AGR, he said, if the HTGC (High Temperature Gas Cooled) development work on graphite-clad ceramic-fuel reactors progresses rapidly.

Sizewell Cut to 550 Mw

Britain's seventh civil nuclear power station, planned for Sizewell in Suffolk, has been scaled down. Minister of Power Richard Wood gave permission to build a 650-Mwe station Jan. 28, but invitations issued Feb. 19 to manufacturers to bid were for two reactors totaling only 550 Mwe. The early figure had been a possible maximum, not a firm estimate; but the British nuclear power program of 5–6-million kw by 1966–7 is now more remote. Sizewell is to cost $170–180-million, to be ready in 1965.

In the light of the foregoing, it is now apparent that CEGB can afford to wait for some beryllium data and some operational experience from the Windscale AGR, due to start up early next year, before abandoning magnox.

Industry proposals to build the Dungeness and Sizewell stations are due at CEGB in June, a few weeks apart, with contract awards expected to be announced about a month after bid receipt.

New Graphite Problem

Meanwhile a new headache has arisen for the builders of the civil stations, in the wake of Cottrell creep of uranium, Wigner growth of graphite, and the beryllium–stainless steel problems. This is graphite shrinkage.

It turns out that at the higher temperatures and fluxes experienced in central core regions, graphite shrinks —whereas under the lower flux and temperature conditions at core edges it swells. In effect, the outside of the core moves away from the center, leaving or tending to leave the core structurally unstable, wherefore any vibration can prevent the proper operation of the controls rods, of fuel loading, etc.

In all the core designs this shrinking characteristic was not allowed for. This was the major reason for the delay on concluding the sale of the General Electric Co.–Simon Carves Calder-type reactor to Japan (NU, April '59, 24; Nov., 28; Feb. '60, 26). The problem was overcome by adoption of hexagonal carbon elements keyed together. But for the CEGB reactors now building, the graphite has already been machined. Nuclear Power Plant Co. solved the problem at Bradwell—at the cost of some reactivity—by inserting zirconium frames between the graphite blocks, so that any moderator movement will be controlled by the zirconium.

New Company Line-up

The line-up of British reactor-building companies has undergone a considerable transformation in the past few months, as result not only of the amalgamation of two pairs of the five original consortia, but also of developments in the international and the British maritime reactor fields.

Most important of the domestic changes is the amalgamation of the AEI–John Thompson group with the Nuclear Power Plant Co. (NU, Feb. '60, 26). The Nuclear Power Group, as the resultant super-consortium is known, now has three projects: Bradwell and Berkeley in England (300 and 275 Mwe respectively, from two reactors each), and Latina in Italy (200 Mwe, one reactor).

TNPG is working with U. S. General Electric on boiling water reactors for shipboard application.

Another pair of consortia, General Electric Co.–Simon Carves and Atomic Power Construction Ltd., have agreed to collaborate on all future nuclear activities (NU, Nov. '59, 29), but without affecting existing commitments of either group. These include the 320-Mw(e) two-reactor Hunterston station near Glasgow and a 150-Mw(e) one-reactor plant at Tokai in Japan for GEC, and the 500-Mw(e) two-reactor Trawsfynydd station for APC.

In the fifth of the original consortia (third remaining group), English Electric is still tied to [British] Babcock & Wilcox for any development of the Calder-type system for use in Britain, but acts independently for other reactor types and for sales efforts abroad. EEC–B&W is building the 500-Mwe two-reactor Hinkley Point Station.

The Independents

Also interested in reactor work are a number of companies that were not a part of the original consortium system. These include De Haviland, Hawker Siddeley, and Vickers, interested principally in nuclear ship propulsion (Hawkers also builds Jason [Argonaut-type] training-research reactors); Humphrey & Glasgow, small and package central stations; and Mitchell, interested in both marine and land applications.

Mitchell's Two U. S. Loves

Mitchell Engineering Ltd. of London, which has a long history of involvement in nuclear power but has always been outside the consortium system, has entered collaboration with another U. S. firm: Combustion Engineering, in addition to and separately from its collaboration with AMF Atomics.

In both cases the origin of the tie is to be found in the person of Walter Zinn. Mitchell employed Zinn as its design consultant when it first entered the field, owing to his pre-eminence in the boiling-water reactor field. Out of Zinn's former association as outside consultant to AMF Atomics was born the Mitchell licensing agreement with AMF. At the time Zinn ended his link with AMF, when he became a vice-president of Combustion, Mitchell was just preparing to submit a boiling-water maritime reactor design to the Galbraith Committee (NU, June '59, 25; Aug., 76).

The link with Combustion proved particularly useful to Mitchell in the marine field. According to a company spokesman, Zinn's brilliant personal advocacy of the BWR before the Galbraith Committee is believed to have done more than anything else to overcome positive hostility to the BWR system in both Admiralty and Atomic Energy Authority quarters due to a complex of political, economic and design factors. Mitchell, however, still retains the link with AMF for land-based applications.

Mitchell now sees a much brighter future for its BWR marine applications in view of the Galbraith recommendations in favor of BWR and organic systems. (However there is still continuing hostility to American-type reactors in general.) Its only effective rival is represented by the tie-up recently between John Thompson and International GE.

The decision as to which reactor system to develop for commercial maritime use is still wide open, according to reliable British sources. Greatly in favor of the OMR is its low enrichment which would not be beyond British enrichment capacity. But this largely-political factor is mitigated on economic grounds owing to the much shorter refueling life, as compared to the BWR's three-year core life.

U. S., Euratom Revising Venture; SENN, Givet Advance

The Administration has accepted the failure of the present 1-million-kw arrangement with the six Euratom countries of Western Europe and, for the past few weeks, has been hard at work on a new arrangement recognizing the changes in Western Europe's power needs since the present agreement was worked out.

AEC Chairman John A. McCone readily conceded the impossibility of meeting current goals of the joint venture last month.

McCone subsequently announced at the "202," state-of-the-atom hearings (*page* 25) that AEC had completed a review of the arrangement with Euratom and decided to: 1. go ahead with an invitation at the appropriate time for construction of two reactors by the end of 1965; and 2. hold the joint research program about where it stands now until two such reactors are scheduled. AEC officials said the two expected to be eligible for the '65 deadline were the French-Belgian Givet reactor (below) and one of several others under study. If more than two are proposed, AEC might seek to extend the program at that time.

Meanwhile, the joint research program is at a standstill (virtually frozen around the SENN project) over Euratom objections. It was felt in Brussels that the program should be kept alive for research on reactors "eligible" to meet the '65 deadline; AEC vetoed this with the argument that the reactors should first be formally proposed.

SENN, Givet, AKS

Meanwhile, there were these developments on Euratom reactors:

SENN. The joint Euratom evaluations board cleared for fuel guarantees the General Electric boiling-water reactor under construction for Italy's Societa Elèttronucleare Nazionale; SENN has not sought loan money under the program because it is borrowing $40-million from the World Bank. The proposal, with fuel guarantees, must be reviewed by both Euratom and the U. S. Congress.

There had been a chance, until a self-imposed Jan. 31 deadline, that SENN might have ordered a "developmental" rather than "proven" first core, in which Euratom would have participated financially. However, it was decided to go with the original core but make some changes in nonreactor equipment—such as a steam drum—to give the station a capability of 225 Mwe. Such "debottlenecking" is not expected to affect power output with the first core (160 Mwe), according to GE officials but will permit upsizing to 225 Mwe with future cores. Foundation piles for the station are being driven at the Garigliano River site north of Naples and full-power target date is still Nov. 1, 1963.

Givet. The Franco-Belgian reactor projected for Givet, on the French side of the Belgian border, remains scheduled for April selection of a reactor contractor. The sponsoring utilities had selected two proposals as a basis for further negotiation—those of Framatome with Westinghouse and International General Electric (NU, Feb. '60, 23). But when the AKS project collapsed, Dynatom-Atomics International was reinvited to negotiate on an organic-moderated reactor.

Though the Givet utilities have committed themselves to only one reactor under the Euratom program, their negotiations with manufacturers cover two plants—one for completion by 1964, a second for end-1965.

AKS. What amounts to the last coffin-nail for the German AKS group's organic-moderated reactor was driven early in February when the German government refused to increase its financial support for the project. The Atomic Ministry had given a $24-million guarantee for operational losses and a further commitment to absorb 70% of losses in the first year of operation if the reactor delivered electricity for less than 3,500 hr.

A smaller group within AKS was reported to be considering a prototype-sized organic reactor—around 75 Mwe. This group is still "sold" on the organic concept, it is understood, but could not raise the funds for a 150-Mwe plant.

Training Reactor Grants Halted by AEC—No Funds

A halt to training-reactor grants for colleges and universities (for nuclear-engineering education) has been forced on AEC by a lack of funds. It may or may not be temporary, depending on Commission and/or Congressional action next fiscal year and beyond on equipment-grant budgets.

None of the $1.8-million available for nuclear-engineering equipment grants this year was released for the 10-kw-type teaching reactors because AEC wanted to spread these funds as far as possible; 56 grants were made, including 19 for much less expensive subcritical assemblies.

Moreover, only $2-million has been requested for reactor-equipment grants in the new fiscal year beginning July 1. AEC officials said they did not know whether any of the $2-million, if it is approved by Congress, would be committed to training reactors but that AEC was still accepting applications for this type of aid. "At least half a dozen" applicants were directly affected by the decision this year to withhold reactor money; total equipment-grant backlog is about $5-million, according to AEC.

Continue All Grants?

The Commission staff has recommended continuation of all campus-equipment grants through fiscal 1964 (NU, Nov. '59, 31), including those sponsored by the Division of Biology and Medicine and the Office of Isotope Development. Reactor-equipment grants would be doubled in fiscal 1962, then tapered off in '63 and '64. The Commission has not yet acted on the staff paper.

The shortage of teaching-reactor funds is bad news to the reactor industry, as well as those schools still looking for help. Most of the 30 reactors installed or ordered to date have been AEC-supported; they represent about one-eighth of the nation's engineering schools.

The aim now, subject to action by the commissioners, is to hold the program open until 1965 for other engineering schools and for arts-and-science schools with a four-year engineering curriculum. Continuing the grants program through '64—for equipment of all types, including some reactors—would help to build a manpower pool for an industrial upsurge foreseen in the period 1968–70.

Stanford Accelerator Cost Brings Second Thoughts

The future of the 15–45-Bev Stanford accelerator (NU, Oct. '59, 20) was very much in doubt last month as Chairman Clinton P. Anderson of the Joint Committee on Atomic Energy indicated he might oppose it and the Administration itself was reconsidering the commitment of more than $100-million the project would cost.

On Capitol Hill, Sen. Anderson (D–N. M.) expressed concern that the U. S. might be overspending for high-energy physics. Estimating that the original $105-million construction estimate for Stanford might turn out to be close to $200-million, he commented:

"I'm not at all sure it's going to be approved."

He said it might make more sense to use the Stanford funds for civilian reactor development: for example, for financial aid to a 300-Mwe reactor AEC is anxious to have a utility sponsor (see page 21); and for increased research on such things as fuel-cycle development and heat transfer.

Administration Turnabout?

The expense of Stanford was also causing second thoughts in the Administration. Because the project was one that had already been approved by the White House and Budget Bureau and sent to Congress for approval it was expected that the Administration would simply renew its pressure on Congress to authorize it early this session. Instead, the project has been carried through a full-fledged re-review by AEC, its General Advisory Committee and by the Scientific Advisory Committee to the White House.

Latest cost estimate at the site proposed last year—at the Stanford campus—has risen to about $128-million. However, alternative sites in the San Francisco area have also been studied and construction at either of these would be closer to the original $105-million estimate. Reports from the West Coast said best alternative sites were near Moffett Field below San Francisco and across San Francisco Bay in Alameda County.

The latest site and cost studies were conducted by J. A. Blume Associates, San Francisco.

Gas-cooled Session Cites Truck-Mounted Reactor

Design details on the Army's ML-1 truck-mounted reactor provided one of the highlights of a two-day symposium in Philadelphia on gas-cooled reactors sponsored by the local American Nuclear Society chapter and the Franklin Institute. First to focus on gas concepts, it drew an overflow attendance of 408 gas-cooled enthusiasts from the U. S. and 11 foreign countries.

ML-1 (sketch NU, Sept. '57, 30), now in final stage of design and initial stage of fabrication by Aerojet-General Nucleonics, is to start operating in mid-1961 at the Idaho test station. The 300–500-kwe unit is fueled with uranium dioxide ceramic elements, cooled by 310-psi nitrogen entering at 800° and leaving after a single pass, at 1200° F to a closed-cycle gas turbine. Moderation is by unpressurized light water, circulated to cool it. Shielding is based on tungsten, said to be considerably more dense, and significantly lighter in total weight, than a lead-based shield. The reactor is to be controlled from a separate cab located 500 ft from the reactor. Fuel element lifetime is in the 3,000–10,000-hr range, and field refueling can be accomplished in 72 hr. Interest also ran high in the largest gas-cooled reactor the U. S. has actually undertaken.

The 25-Mwe **Oak Ridge Experimental Gas-Cooled Reactor** will have eight experimental loop systems each having an independent coolant circuit permitting use of different coolant gases, and capable of generating power in the reactor with fuel materials of full-scale capability. Each of four of the loops will be able to handle 2 Mwth, each of the other 0.5 Mwth. Thus the reactor will also serve as an experimental tool to help develop and test advanced gas-cooled fuel materials. It is to be in operation by end 1962.

REACTOR NEWS

FERMI CORE IN TROUBLE; SYLCOR DROPS JOB

Designers of the Fermi fast breeder suffered a setback last month when it developed that the "birdcage"—the core component that holds together the 144 fuel pins that make up a fuel element—requires redesign. Fermi's designers are borrowing specialists from Westinghouse and NDA, feel the problem can be solved in time to maintain schedule: loading fuel by year's end.

Technical backdrop. The birdcage is a series of alternating transverse wires used to support the pins along their length and maintain fuel homogeneity under all operating conditions. However out-of-pile endurance tests in 950° F sodium at full flow have shown that the nonsymmetrical pin support resulted in forces causing the pins to creep away from support wires; the designers fear this could result in a loose, nonhomogeneous bundle of pins within the element can during operation due to pin bowing as result of large temperature gradients. This could affect ability to maintain stable reactor control—one of the main issues in the unions' long fight over Fermi's safety. Problem is to support the pins and prevent bowing without interfering with sodium flow.

Meanwhile Sylcor, one of two manufacturers each making a Fermi core, has asked to be released from its contract to produce 100 core elements (14,400 pins). Sylcor is doing well making blanket elements. The other core maker, the Nuclear Metals Inc.–D. E. Makepeace team, is making better core pins than Fermi's builders thought they could get, and has been asked to take over the core Sylcor dropped.

DRESDEN RELOADING

All 80 control rods of the Dresden reactor were replaced (NU, Feb. '60, 25); core reloading began Feb. 3 and criticality attained Feb. 11 with 144 elements, resuming the low-power testing interrupted Nov. 6.

SRE CLEANUP WORK CONTINUING

Atomics International last month completed cleaning up —entirely by remote handling—the top of the SRE core, where 75 uranium slugs or pieces of slugs had spilled when fuel elements damaged in the July 27, 1959, mishap were being withdrawn (NU, Dec. '59, 23; Jan. 107). The crew is now going after the bottom halves of fuel elements that remained in their channels, will pull out the entire moderator can containing the channel if the debris is jammed. AI is ready to pull as many as 20 cans, if necessary; at least three are known to require replacement. All this work must be done through the top shield, with one of five specially-designed grappling tools installed through one of the shield plug's 3-in. holes, and with a periscope and lights installed through adjacent 3-in. holes. Cover-gas activity (argon is used for the cleanup operation in place of the usual helium) is 10^{-4} microcuries/cc. If the cleanup moves along on schedule, SRE may be critical again in April, with its second core—uranium-thorium—that is expected to yield 6,000 Mwd/ton burnup, as against the first core's 1,100.

BLAW-KNOX STUDYING ANP INDIRECT CYCLE

AEC has asked Blaw-Knox Co. to determine what facilities are needed to test an indirect-cycle aircraft reactor. Amount of the contract for the two-month study was not disclosed; it is a result of AEC's decision to build a first experimental indirect-cycle aircraft reactor at the Idaho testing station. All existing Aircraft Nuclear Propulsion facilities at Idaho were designed for General Electric's direct-cycle reactor program. Last summer the Pratt & Whitney indirect-cycle system, long in the shadow of GE's direct-cycle approach, got a green light of sorts (NU, March '59, 20; Sept., 28).

SPERT 4, SAXTON CONSTRUCTION STARTING

Newest in the series of SPERT (Special Power Excursion Reactor Test) reactors—which, with KEWB, form AEC's facilities for reactor safety studies, SPERT-4 neared groundbreaking at the Idaho test station. The $2-million unit, an open pool like SPERT-1, will permit close control of water temperature and volume to study stability effects. It is due for summer 1961 completion. . . . Ground was broken for the 5-Mwe Saxton pressurized-water reactor Westinghouse will build for Penn Electric.

KIWI-A' WORK STARTING AT JACKASS FLATS

Successor to Kiwi-A, successfully tested last summer (NU, Aug. '59, 23), Kiwi-A' is getting under way; preparatory field work started last month at AEC's Jackass Flats, Nev., test site. The experiments with this second reactor in the Rover nuclear rocket program are to be run this summer.

YANKEE, ELK RIVER VESSELS SHIPPED

The Yankee reactor's pressure vessel left Babcock & Wilcox's Barberton, Ohio, shops last month and arrived at the Rowe, Mass., site a week and 850 rail miles later. The 165-ton shell, 27 ft long and 13 ft wide, cost about $1.5-million . . . Elk River also got its vessel, a 72-ton, 25-ft long, 7 ft dia shell, from Pacific Coast Engineering (Paceco) shops at Alameda, Calif.

ARMY ORDNANCE PLANS 4 REACTORS

For its weapons development program, Army Ordnance plans to build four research reactors. A 20-Mwth modified ORR (Oak Ridge Research Reactor) will be built at Picatinny Arsenal, Dover, N. J. (another for Frankfort Arsenal, Philadelphia, has been dropped). For Abderdeen Proving Ground, Maryland, Aerojet-General Nucleonics is designing a neutron-pulse reactor, OPERA (Ordnance Pulsed Experimental Research Assembly), to yield 10" fast neutrons per pulse or operate at 100 kw steady-state. Two other pulsed reactors are planned for Diamond Ordnance Fuse Lab, Md., and White Sands Proving Ground, N. M.

AI: TWO NEW CRITICALS, NEW KEWB CORE

Atomics International started up a critical assembly to determine fuel requirements and evaluate power, control and instrument systems for the Hallam, Neb., 75-Mwe sodium-graphite reactor; and at the same time broke ground on another critical facility for its Advanced Epithermal Thorium Reactor (NU, Sept. '59, 29). AI has also installed a second core tank in its KEWB (Kinetic Experiment on Water Boilers) homogeneous reactor, a part of AEC's reactor safety study program. The new tank, cylindrical instead of spherical, will permit power peaks nearly triple the record 530-Mw(th) obtained with the first core in a 1/100 sec surge.

SIX MANUFACTURERS BID ON SSPWR

At least six bids have come in to AEC to build the 16.5-Mwe Small-Size Pressurized Water Reactor (NU, Feb. '60, 17). AEC refused to disclose bidders' names, but these are known to have bid: Alco, Allis-Chalmers, American Standard, Babcock & Wilcox, Combustion Engineering and Westinghouse.

WORLD NEWS

Russia, U. S. Offer India Reactor Aid

The Russians have offered to help India build a thorium-burning power reactor, and the U. S. is expected to provide technical and financial aid on a second, 250–500-Mwe unit, according to NUCLEONICS' Bombay bureau. Vasily S. Emelyanov, chief of Soviet civilian nuclear work, led an experts' team to Delhi last month, and a U. S. team is also expected there. The U. S. is understood to have offered a long-term loan to meet India's foreign exchange shortage, a major obstacle. India's AEC has suggested construction of three nuclear plants with a total capacity of 1,000 Mwe during the third Five-Year Plan starting in April 1961, but the government, racked by the currency shortage, has approved only one 250-Mwe plant, costing $90-million; it will be at Ahmedabad, will use enriched U.

U. K. Invites Tanker Bids

Five tanker-reactor designers have been invited to bid by Britain's Ministry of Transport on a nuclear propulsion unit for a 65,000-ton deadweight vessel. English Electric, which recently concluded a cooperation agreement with Atomics International, is offering an organic-moderated reactor. Only Hawker-Siddeley will submit a British-designed unit, also organic-moderated; the other four are all based on American types (boiling-water and organic). Also invited to bid were Mitchell Engineering Ltd., the Nuclear Power Group, and Babcock & Wilcox Ltd.

Italy Planning Organic Pilot Power Plant

A 30-Mwe organic-moderated reactor is planned in Italy as a joint government-industry project. CNRN (the National Commission for Nuclear Research) would organize the project and finance the reactor, AGIP Nucleare would design it, and SORIN (the Fiat and Montecatini group) would build it. Cost is put at $10-million; Bologna has been mentioned as a possible site. The turbogenerator would not be installed until after the first uranium-oxide core had been burned to permit design of an improved second core.

Japanese Ship Survey Team Would Buy American

The report of the 21-man Japanese team that toured the U. S. and Western Europe this winter has been submitted to government agencies in Tokyo. Its recommendation: import of reactors for marine use from the U. S. on a commercial basis. However strong opposition to this position was expressed by the new Minister of Science and Technology, Yasuhiro Nakasone (NU, Nov. '59, 28), who favors pushing domestic reactors.

Bern Okays 2 (of 3) Reactors, Würenlingen Takeover

The Swiss federal government gave a green light last month to two all-Swiss pilot power reactors while cold-shouldering a third, U. S.-imported project. Winning government support to share in a Sw.fr. 50-million ($11.5-million) subsidy over five years are ENUSA (Energie Nucléaire S.A.) of Lausanne, and the Consortium for Construction of a Research Nuclear Power Plant, of Zurich.

Failing to win government backing was Suisatom S.A., in which Brown Boveri and several utilities are interested (NU, Sept. '57, 27) but which was to use largely private financing for its planned 15-Mwe GE boiling unit.

The government message said that because the projects have the same aim—study of economic feasibility—to push all three simultaneously would result in duplication as well as overtaxing available resources. It said explicitly it was choosing Consortium and ENUSA because their plans call for Swiss-built reactors. Consortium, comprising eight large industrial firms headed by Sulzer, plans a natural U, heavy water reactor of 6–8-Mwe, underground, costing $12.8-million. ENUSA includes 15 firms in the French-speaking cantons headed by Sécheron, and plans a 5-Mwe boiling water, slightly-enriched-oxide unit, underground, to cost $9.3-million.

The government also asked Parliament for authorization to take over the Würenlingen nuclear research center May 1 from the private syndicate Reaktor A.G., which cannot afford to continue operating it (NU, Aug. '58, 26). It will be attached to an Institute for Reactor Research of the Federal Polytechnic Institute at Zurich. The government has so far poured $11.6-million, and private industry $5.8-million, into Würenlingen; it's estimated $2.3-million more is needed to complete it, $1.4-million to operate it from May 1 to Dec. 31, 1960.

Germany: A Step Forward, One Back

The Bonn Atomics Ministry has made available $360,000 toward a design study for a pressurized-water, 20,000 hp reactor to drive a merchant ship. Howaldtswerke, Hamburg, and Siemens-Schuckert are doing the study. . . . RWE of Essen, West Germany's biggest utility, builder of a 15-Mwe nuclear plant and long planner of a 250-Mwe one, has decided the full-scale plant would be premature now and has just about abandoned it.

German Research Reactor Delayed

The first all-German-designed and -built reactor, the FR-2 research unit at Karlsrube (NU, Dec. '59, 26), will go critical only at the end of this year, almost a year later than originally planned. Some unidentified metal parts for the core failed to meet requirements in chemical and X-ray tests, and a new lead-coated steel tank is required.

B&W in Nuclear Ship Tie in Italy

Babcock & Wilcox moved into the European nuclear shipbuilding field with signature of a ten-year collaboration pact with Italy's second largest shipbuilders, Cantieri Riuniti dell'Adriatico [United Shipyards of the Adriatic]. Under the agreement Cantieri Riuniti may build merchant ships powered by reactors of B&W design, sell them in or outside Italy. The agreement also includes patent licensing in certain areas, technical assistance in applying the nuclear power plant to the ship, and contemplates the possibility of B&W's supplying nuclear components.

Vickers Gets Triga Sales License

Vickers-Armstrong will make and sell Triga reactors in Britain under a licensing agreement concluded with General Atomic division of General Dynamics Corp. Vickers will make the 10–100-kw solid-homogeneous research and training unit at its South Marston, Wiltshire, works, will sell them in Britain for under $280,000.

Two British-Powered A-Subs for Royal Navy

Britain will order two all-British nuclear submarines, the 1960–61 defense budget shows; they are in addition to the Westinghouse-powered *Dreadnought*. The land-based prototype for the all-British submarine reactor at Dounreay may go critical by December.

NEWS IN BRIEF

LeClair Joins General Atomic; Powers to Purdue

In two surprising management switches announced last month: Titus G. LeClair, top nuclear man at Commonwealth Edison, is joining General Atomic about March 1 as manager of nuclear applications; and Philip Powers, president of Internuclear Corp. since its founding in 1955, is reporting to Purdue Univ. at the same time to organize a Nuclear Engineering dept. Powers will continue as a member of the Internuclear board and retain his financial interest in the firm (he's the largest stockholder). As to why he left Internuclear, he said: "I've been thinking about doing something like this for a long time and it looks like fun. . . . My departure from the company should not be interpreted [as Internuclear's giving up on atomic energy]." Though the company is finding nuclear business hard to get, he said, "it is doing very well and making money." Because of the failure of a strong nuclear demand to develop, however, Internuclear is beginning to look at "some nonnuclear things," he said. One of these is consultant work on high-speed electronics, where the firm has already had some experience. "There are other things in life beside the nuclear field," Powers commented.

LeClair

Powers

On Feb. 6, shortly after the announcement that Powers was shifting to Purdue, the Internuclear board voted to sell the firm's assets to Petrolite Corp., a St. Louis petrochemicals supplier. The deal—an exchange of stock—was expected to be approved by the stockholders at the end of February. Powers said there would be no change in Internuclear's modus operandi.

Latin America, Mid-East to Get AEC "Road Shows"

AEC is putting together two "road shows" on atomic energy—one for Latin America, the other for the Middle East. Both have been designed to permit experimental work by local scientists during a three-week exhibition period. The first to open will be at Cairo May 8, featuring an Argonaut-type training reactor, a 2,500-curie cobalt-60 source built by Brookhaven Laboratory, a reactor simulator and a technical library; the same exhibit will be shown at Karachi, Pakistan, in November. A separate exhibit will open in Buenos Aires in September and is tentatively scheduled for Rio de Janeiro in January of 1961, Caracas, Ven., the following June and Lima, Peru, in October '61. It's almost identical to the Mid-East exhibit except for the reactor, which will be a Lockheed training reactor modified for mobility.

ORNL Pondering Containment for Reprocessing Plants

Containment for chemical reprocessing plants may be recommended by Oak Ridge, upon completion of a reevaluation of reprocessing procedures the lab is now doing following the Nov. 20 accident at the Thorex Pilot Plant (NU, Jan. '60, 28). The adjacent X-10 graphite reactor was shut down until Dec. 22 due to the mishap. Decontamination of the area affected was to be "essentially" completed by Feb. 15, ORNL announced last month. Cost of decontamination is expected to range $250,000–350,000. The accident was nonnuclear in origin: an organic cleaning solvent in a Thorex cell encountered some nitric acid and exploded, but this scattered some 600 milligrams of plutonium. No one was overexposed, AEC said.

April 1 Goal for Final Indemnity Rule

AEC's permanent reactor indemnity regulation, spelling out financial protection required of reactor owners under the Price-Anderson Act, is being readied for promulgation by April 1. The Commission's staff would like to be able to report to the Joint Committee on Atomic Energy that this long-argued job is done when it makes its annual report under Price-Anderson. However, insurance industry's representatives have voiced major criticism of the regulation as it now stands, particularly the proposed financial-protection minimums for small reactors. They feel that a 1-Mw research reactor in a densely populated area, for example, could do far more damage than the $1.5-million in protection required by AEC. They said commercial premiums may have to be raised.

AEC Competition Study to Take a Year

AEC's study on competition with industry (NU, Jan. '60, 22) will take about a year to complete, according to Budget Bureau spokesmen. Most government agencies reported to the Bureau of the Budget—under the Bureau's Bulletin 60–2—on Dec. 31; but AEC and the Defense dept. were given extra time because of their huge programs and because the Budget Bureau, for the first time, asked for a review of work done by operating contractors.

Williams Undergoes Cancer Operation in Minneapolis

Commissioner John H. Williams, AEC's scientific member, underwent surgery for cancer on Jan. 19. Williams had had a chest operation several years ago and was thought to be safely beyond the period for a recurrence. Fears mounted that he would have to resign his post.

GE Moves Atomic Power Dept. into Utilities Group

General Electric has moved to mate its nuclear-power operation with its other major departments serving the utility industry. The Atomic Power dept. under Lyman Fink (including Hanford) has been moved into the new Electric Utility Group, under Clarence Linder. In other changes, the Aircraft Nuclear dept. has been assigned to the Electronic, Atomic and Defense Systems Group; former ANP manager Roy Shoults has succeeded Frank McCune as the corporation's nuclear development representative; and Samuel Levine (as acting manager) has succeeded Shoults (*see page 162*).

Management, Labor Cooperating on Worker Education

The International Brotherhood of Electrical Workers and five reactor-building or -operating utilities have embarked on a cooperative program to educate workers on steps being taken for safe reactor operation. Details of the program have yet to be worked out but two utilities have already designated their representatives in negotiations to get the program moving. The others are expected to follow suit soon. Participating utilities are Commonwealth Edison, New England Electric System, Power Reactor Development Corp., Northern States Power and Duquesne Light. What IBEW officials call a "rump" effort to develop a worker-education program for Shippingport is being sponsored by the AFL-CIO Industrial Trades dept. and the Pennsylvania Labor dept. IBEW said neither it nor Duquesne is participating in this effort.

RADIATION NEWS

Russian Sees Big Things for Radiation in Oil

Echoing a point of view once widely held in the U. S., L. S. Polak, chief of the Laboratory for Radiation Chemical Processes of the USSR Institute for Oil Chemical Synthesis, predicted last month that radiation will revolutionize oil refining and lead to the production of hundreds of new polymers. On refining, he said radiation thermal cracking would increase yields from crude oil by 4–5 times at any given temperature. On new polymers, he said radiation may permit conversion of oil directly into plastics, medical products, alcohol and synthetic rubber—bypassing several stages in ordinary refining. The biggest problem, Polak said, was to "find a sufficiently effective method of separating radiation products."

Gas Measuring Devices Under Development for Govt.

Tracerlab is developing clathrate devices for the National Aeronautics and Space Administration and for government weather experts, peaceful and military. The devices will measure ozone and other gases far above the earth by releasing "caged" krypton-85 in amounts proportional to the gas being measured. Accuracy is in parts-per-billion.

AEC Releases Isotope Report, Seeks $500,000 Boost

A long-delayed report on its Isotope Development Program was released last month by AEC. The report highlights progress during the first year of the program and new isotope applications under exploration. It was originally prepared for last summer's semiannual report—as something of a swan-song for former Commissioner Willard Libby—but AEC went on an annual reporting basis before the July semiannual could be published. The isotope report was then prepared for fall publication by the Government Printing Office but objections to some of its wording by AEC Chairman John McCone and others delayed publication until last month.

The delay may be beneficial to the Isotope Development Program, however, because the progress report comes as AEC renews its third annual plea for IDP program funds. In both prior years, the program's budget has been cut by the House Appropriations Committee. AEC's request for fiscal 1961, beginning July 1, is $4.5-million, or $500,000 more than the current year's budget, including funds for all activities of the Office of Isotope Development. The breakdown, most of it for isotope development contracts: isotope or low-level contracts, $2-million; high-level radiation contracts, $900–950,000; education and training, $450,000; production process development (producing isotopes), $800,000; and equipment chiefly for programs at Oak Ridge and Brookhaven, $400,000. No money has been asked for construction of new facilities.

Current contracts under the high-level and production-processing phases of the program:

1. Radiation Applications, Inc. Extension of two contracts: on the technology of large fission-product beta sources and on the mechanism of radiation-induced reactions of organic polymers with inorganic salts and organometallic compounds. Contracts expire Dec. 30, 1960.

2. Westinghouse. Development of transparent polyethylene by radiation.

3. Engelhard Industries. Effect of radiation on catalytic activity of platinum.

4. Technical Research Groups, Syosset, L. I. Synthesis of semiconductor materials by radiation-induced reactions (silane or other silicon compounds).

5. Battelle. Experiment with the liquid and vapor phases of nitric-acid production via radiation, including work on varying pressures, temperatures, radiation doses and dose rates and nitric-acid concentrations.

6. Air Reduction Co. Fission-product applications using gaseous beta sources, including investigation of krypton-85 effects in chlorine production.

7. William H. Johnston Laboratories. Basic studies in radiation technology, with special attention to nitrogen fixation and production of ethylene glycol from methyl alcohol.

Budd Orders 25,000 Curies Co^{60} from GE

The first major order for cobalt-60 from a private supplier has been given to General Electric by Budd Co.—25,000 curies. The material is being irradiated in GE's test reactor (GETR) to a specific activity of 35–40 curies/gm. Heretofore Budd and other cobalt-60 users had had to rely on AEC and Atomic Energy of Canada, Ltd., for their supply. Budd is also reported to have a strong demand for high-activity cobalt—100–120 curies/gm—and is considering both GETR and the Westinghouse Testing Reactor (WTR) as sources of supply. WTR is expected to go to 60 Mw this spring.

Japanese Firm Gets Sales Rights from RDI

Radiation Dynamics, Inc., Westbury, L. I., has given exclusive Japanese sales rights for its Dynamitron accelerators to C. Itoh Co., a Tokyo trading firm. Under the agreement, RDI will deliver a 1.5-Mev, 15-kw Dynamitron to Itoh this summer, if possible. A prototype Dynamitron recently completed two months of smooth operation—on a 16-hour/day basis. The firm is now offering both electron and positive-ion versions of the machine in a total of five models.

West Coast Firm Changes Name, Boosts Capacity

Raytherm Corp., Redwood City, Calif., has changed its name to Raychem Corp. (radiation chemistry) and has boosted capacity for irradiated-plastic production from 8 kw to 28 kw. Two 10-kw resonant transformers have been purchased from General Electric and plant capacity has been doubled to 60,000 sq ft. The firm is adding a line of new products to its insulated-wire business, in which chemical properties will be more important than heat-resistance.

Fission-Product Plant at Oak Ridge Shut Down

Oak Ridge National Laboratory's Fission Product Pilot Plant (F3P) has been shut down as a result of the chemical explosion there Nov. 20 (NU, Jan. '60, 28). F3P was not directly involved in the accident but it and the plant feeding it raw material have been shut down pending an ORNL safety review. F3P, which will not resume production until late this spring, produces cesium-137, strontium-90, promethium-147, cerium-144 and technetium-99. AEC is trying to line up an alternative feed-materials source for F3P.

Physics Research Lab Established by HVEC

High Voltage Engineering Corp. is establishing a physics research lab for basic and applied neutron studies at its Burlington, Mass., headquarters. A 2-Mev Van de Graaff positive ion accelerator will be specially fitted for neutron work in activation analysis, neutron-output data, and data on target life and design.

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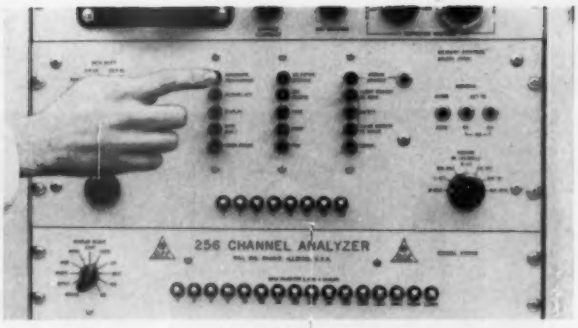

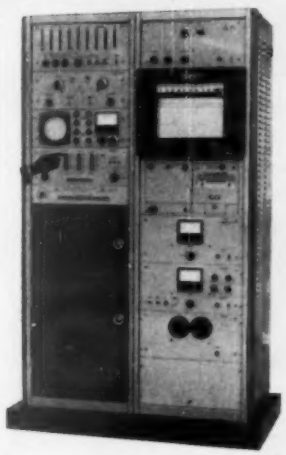

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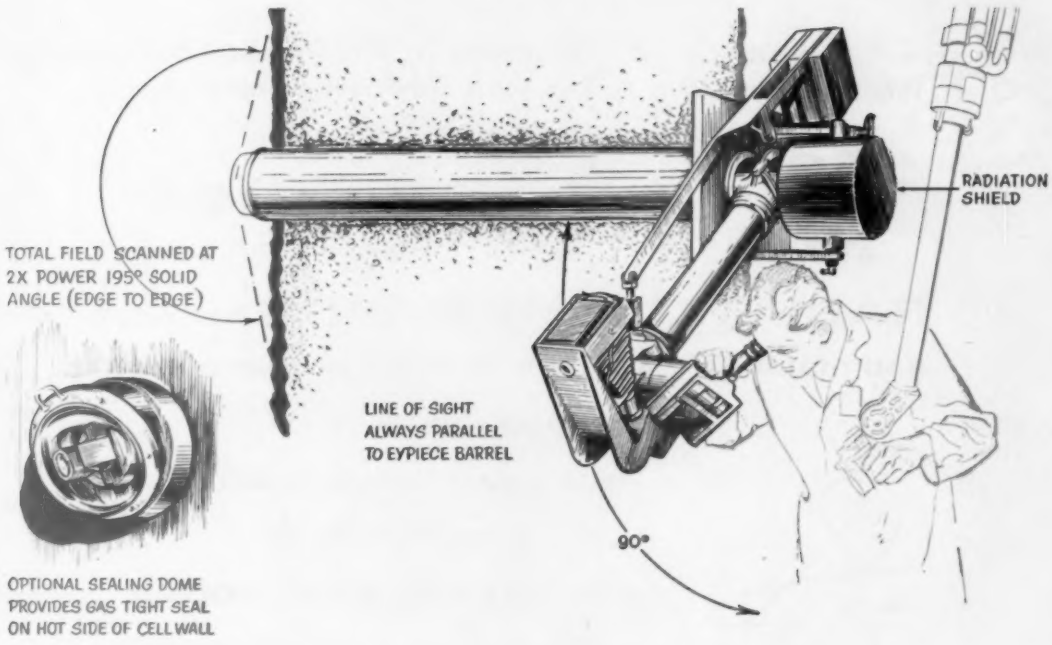

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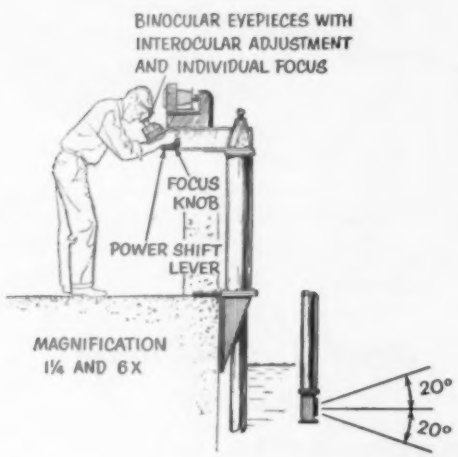

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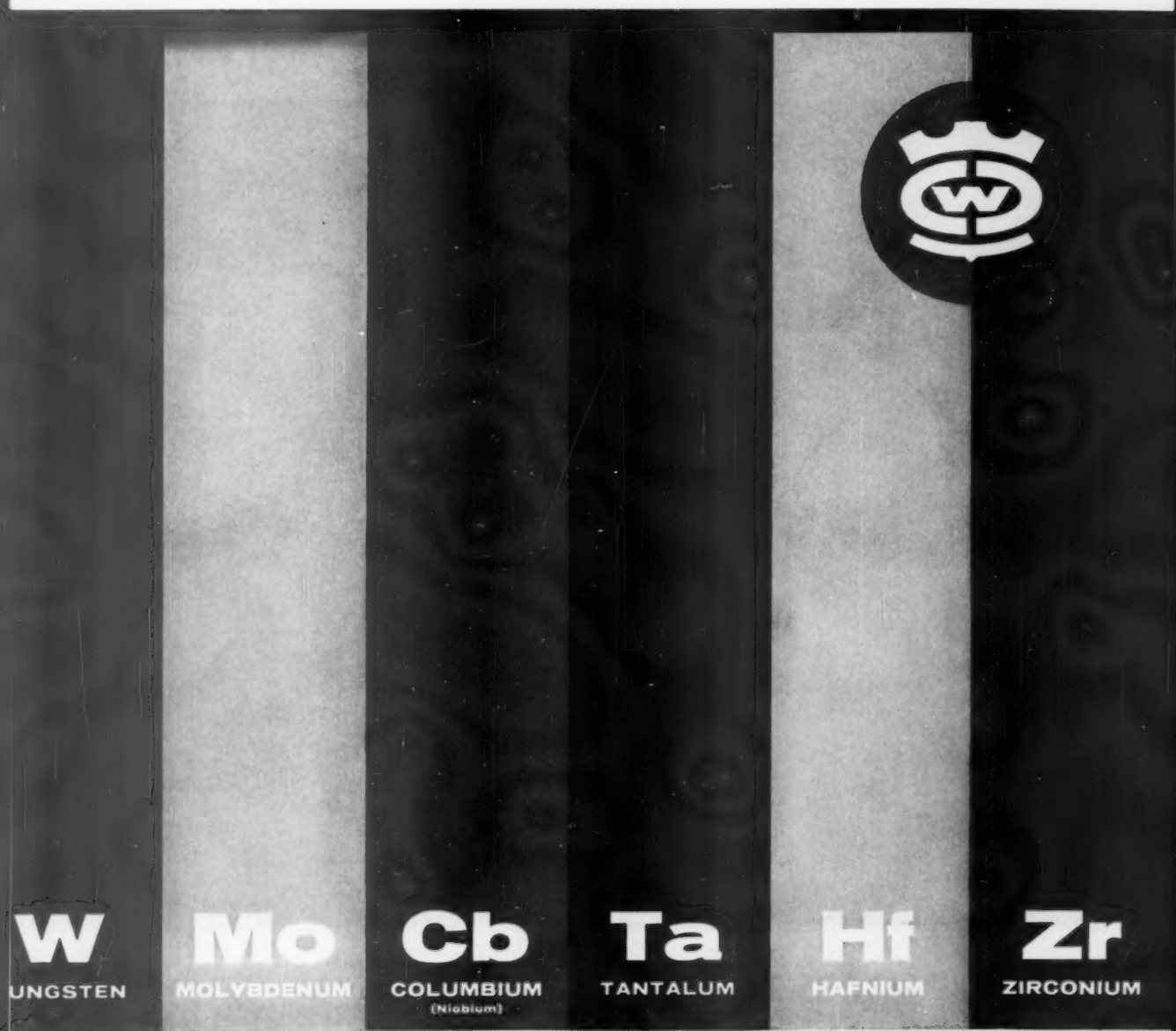

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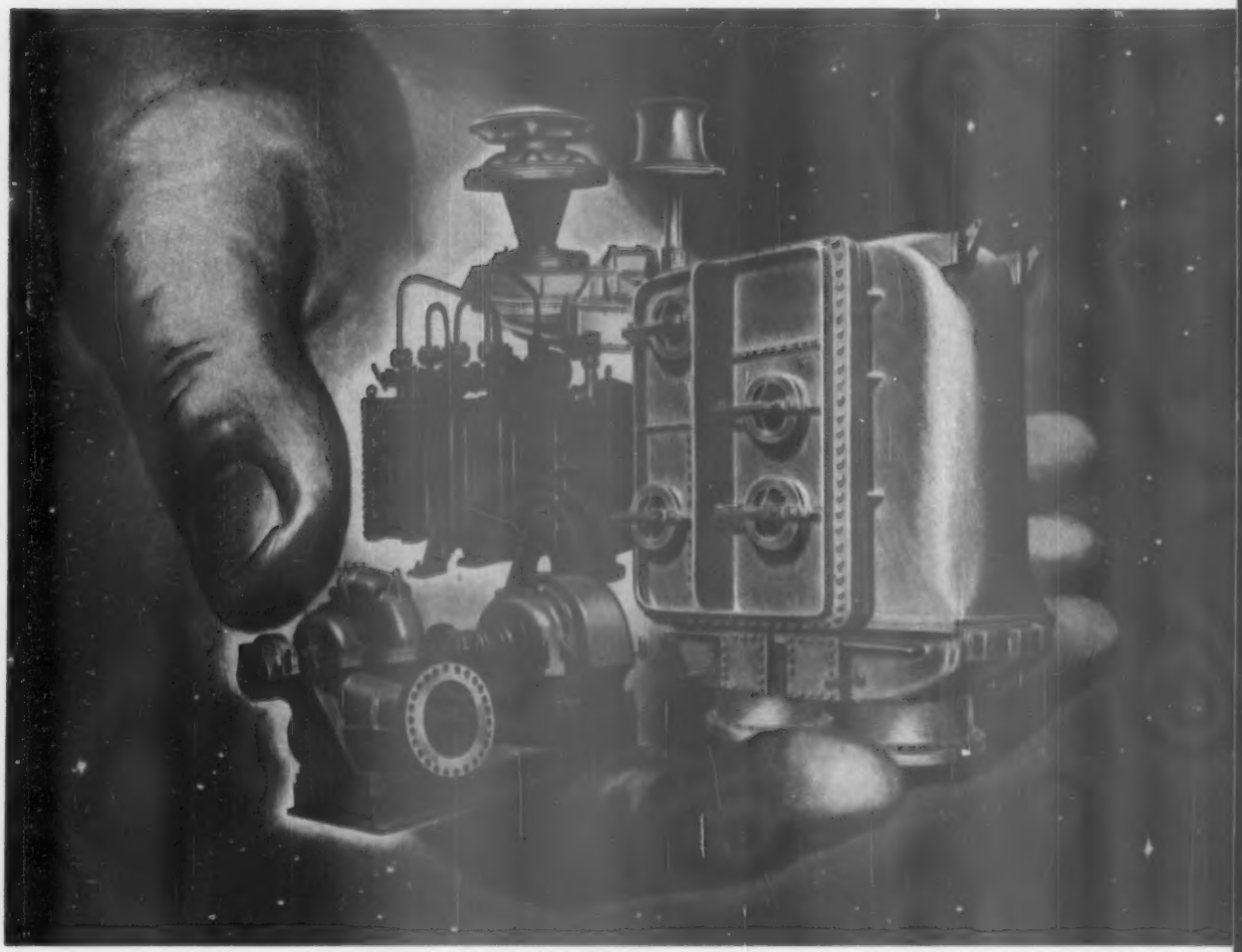

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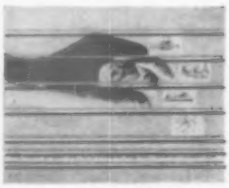

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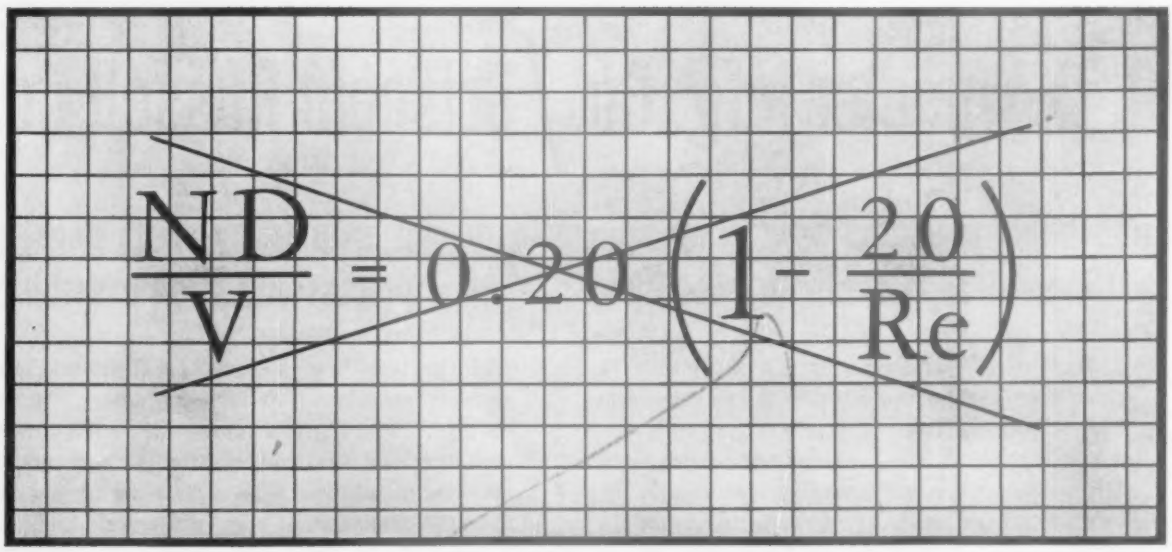
Since Von Karmen vortices or venturi effects are often absent in complex reactor flow and basic definition of the vibration phenomena cannot be described analytically, engineers at the Bettis Atomic Power Laboratory simulate reactor conditions of flow, pressure and temperature that experimentally describe reactor components sensitive to vibration.

If you are a mechanical, electrical or chemical engineer interested in a career in nuclear engineering and are a U.S. Citizen, Bettis Atomic Power Laboratory offers a dynamic program in nuclear system design and test. For additional information, write to: Mr. M. J. Downey, Dept. B-23, Bettis Atomic Power Laboratory, Westinghouse Electric Corporation, P.O. Box 1526, Pittsburgh 30, Pa.



BETTIS ATOMIC POWER LABORATORY

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Concerning programs and professional opportunities at General Atomic Division of General Dynamics

General Atomic is a modern center of nuclear development where new ideas and techniques originate and are vigorously pursued. Here, a wide range of scientific research and engineering programs is underway in an environment which includes a full spectrum of activities combining the traditions of basic research with the dynamic resources of a major industrial organization for engineering and production. Some of General Atomic's activities are described on the following pages.

Left, high-temperature metallurgy experiment for General Atomic's HTGR and MGCR programs. Above, TRIGA reactor core. Upper right, torus, used in fusion experiments. Right, atomic beam apparatus for studying interaction of atoms on surfaces.

General Atomic's advanced activities present unusual challenges . . .

Prime emphasis at General Atomic Division of General Dynamics is the development of new ideas — from their theoretical conception through the successful operation of the finished product. Among the advanced science and engineering programs now underway at General Atomic's John Jay Hopkins Laboratory for Pure and Applied Science at San Diego, California, are the following:

HIGH TEMPERATURE GAS-COOLED REACTOR — The HTGR system, with its unique graphite and carbide fuel-moderator elements, embodies such design characteristics as (1) modern steam conditions of 1000°F. and 1450 psi; (2) helium gas outlet temperature of 1380°F.; (3) fuel burnup in the 50,000-100,000 MWD/ton range; and (4) over-all system efficiency of 35%. The prototype HTGR plant will be completed in 1963 for Philadelphia Electric Company and 52 other utility companies comprising High Temperature Reactor Development Associates, Inc.

MARITIME GAS-COOLED REACTOR — The MGCR system for merchant ship propulsion combines — for the first time in one system — a gas-cooled reactor and closed-cycle gas turbine power machinery. Using a beryllium oxide moderator and uranium oxide fuel, the MGCR permits the achievement of over-all efficiency up to 40%, while making possible low fuel costs and a compact design. The MGCR system is being developed for the U.S. Atomic Energy Commission and Maritime Administration.

DIRECT CONVERSION OF HEAT TO ELECTRICITY — General Atomic's broad activities cover both civilian and defense applications, including the development of high temperature cesium cell and semiconductor devices to operate as integral parts of nuclear reactors. Participating in the civilian program are the Rocky Mountain-Pacific Nuclear Research Group of utilities and San Diego Gas & Electric Company.

CONTROLLED THERMONUCLEAR REACTIONS — The world's largest privately financed program is directed toward a more complete understanding of plasma physics to point the way toward controlling and sustaining a fusion reaction. The theoretical and experimental program is being conducted jointly by General Atomic and the Texas Atomic Energy Research Foundation.

NUCLEAR POWER FOR SPACE VEHICLES — General Atomic is carrying out the U.S. Government's project for the use of controlled nuclear pulses to propel space vehicles, such as a 1000-ton space platform. This dramatic program, called Project Orion, is authorized by the Advanced Research Projects Agency.

TRIGA REACTORS — Extended applications of General Atomic's inherently safe TRIGA reactor are continuously under study at the Laboratory. For example, adaptions of the TRIGA core have been shown to be capable of safe, repetitive flashing, thus opening new fields of research using pulsed radiation. Sixteen TRIGA reactors are now — or soon will be — in operation throughout the world.

RESEARCH AND DEVELOPMENT — As indicated by the summary on the following page, activities at General Atomic go deeper and beyond specific major projects. Some of these other areas, in both basic and applied research, include: advanced reactor concepts, solid state physics, atomic beam studies, high-temperature chemistry, radiochemistry, and the development of new materials.

Activities encompass diverse scientific and engineering disciplines . . .

Intensive integration of diverse technical disciplines at the John Jay Hopkins Laboratory provides an unusually broad exchange of ideas and information between the scientist and the engineer. This philosophy is in keeping with General Atomic's emphasis on closely combining basic scientific research with its applications. Some of the current activities are summarized below:

PHYSICS — Theory of atomic and nuclear cross sections . . . solid state theory . . . fundamental plasma physics . . . basic reactor theory . . . atomic beam studies of charge exchange, atom-surface interactions, and chemical kinetics . . . irradiation effects on solids, gases and liquids, using linear accelerator and TRIGA reactor . . . devices to convert heat directly to electricity . . . high-temperature semiconductors . . . studies of the band structure of solids . . . applications of solid state surface physics to chemical catalysis . . . acoustic studies of single crystals and deformed materials . . . use of pulsed neutron sources for cross section measurement and reactor physics problems . . . development of novel diagnostic techniques to study the confinement and heating of plasmas.

NUCLEAR ENGINEERING — Reactor core design and thermal analyses . . . reactor design neutronic calculations . . . analyses of reactor and system controls . . . evaluation of economics associated with reactor core design . . . operation and analysis of critical experiments and applications of results to reactor design problems.

METALLURGY — Development of materials for harnessing nuclear and thermonuclear energy, involving physical metallurgy . . . mechanical metallurgy . . . high-temperature, high-pressure research . . . effects of fabrication on mechanical properties and stored energy . . . in-pile and post-irradiation studies . . . surface phenomena studies using the controlled atmosphere microbalance . . . refractory materials . . . corrosion studies . . . ceramics, graphite and carbides for high-temperature fuel elements.

MECHANICAL ENGINEERING — Nuclear power plant and equipment layout . . . design of reactor equipment, including: pressure vessels and internal reactor elements, steam generators and other heat exchangers, pumps, compressors, piping and control systems, control rod drives, and remote fuel handling mechanisms . . . unconventional equipment problems involving studies in stress, heat transfer, fluid mechanics, and thermodynamics.

MATHEMATICS — Mathematical analysis and programming involving the numerical solution of linear and nonlinear equations, ordinary and partial differential equations, and integral equations for making calculations in the following areas: reactor criticality, kinetics and burnout, heat conduction, stress analysis, hydrodynamics, and stability.

CHEMICAL ENGINEERING — Selection, specification and process design of fluid systems . . . applications of unit operations in the nuclear power field, involving purification of gases . . . establishment of criteria in process instrumentation . . . reactor fuel reprocessing . . . economic evaluation studies . . . development of test loops.

CHEMISTRY — High-temperature solid-vapor and solid-solid phase equilibria . . . chemistry of compound semiconductors . . . photonuclear reactions and other areas of radiochemistry . . . diffusion and entrapment of fission product elements . . . chemical kinetics . . . gas adsorption . . . carbon transport in high-temperature reactors . . . mass spectrometry . . . activation analysis . . . varied and novel problems in analytical chemistry.

ELECTRICAL ENGINEERING — Systems and components for reactor instrumentation . . . nucleonic instrumentation, including radiation detectors and other experimental equipment for millimicrosecond pulse work . . . solid state DC-to-AC converters.

Above, investigation of thermionic emission of tantalum in Laboratory's direct conversion program. Left, test stand to measure heat transfer characteristics of HTGR fuel elements.

Professional openings for engineers and scientists . . .

Engineers and scientists interested in contributing to the advanced programs outlined on the previous pages are invited to consider openings at General Dynamics' General Atomic Division. Those who qualify will join more than 1000 scientists, engineers and support personnel now working at the John Jay Hopkins Laboratory.

Openings, including senior positions, now exist for the following:

THEORETICAL PHYSICISTS
EXPERIMENTAL PHYSICISTS
MATHEMATICIANS-PROGRAMMERS
METALLURGISTS
CERAMISTS
CHEMISTS
CHEMICAL ENGINEERS
NUCLEAR ENGINEERS
MECHANICAL ENGINEERS
ELECTRICAL ENGINEERS

With a Corporate investment of over $15 million, and total facilities in excess of 300,000 square feet, the John Jay Hopkins Laboratory is now the largest and most diversified privately owned nuclear laboratory in the world. Its facilities include: more than 150 individual *laboratories* in three arc-shaped buildings . . . a *library and technical information center* at the hub of the Laboratory complex . . . *experimental and process metallurgy building*, including research and fabrication equipment, as well as apparatus and high bay space for large-scale engineering experiments . . . a *technical office building* . . . an operating *TRIGA* reactor for both steady-state and pulsed experiments . . . a 300 milliampere, 32 MEV electron *linear accelerator* . . . a megacurie *hot cell facility* . . . *critical experiment building* . . . and *fusion research center*, housing a shock wave and plasma projection facility, a torus, two linear pinch assemblies, and a large storage condenser bank.

The campus-like laboratory is located atop San Diego's Torrey Pines Mesa, less than a mile from the Pacific Ocean. The San Diego area offers many advantages to families residing here — including unsurpassed climate, schools among the best in the nation, expanding advanced education facilities, and limitless opportunities for year-round recreation.

General Atomic welcomes inquiries from qualified scientists and engineers interested in exploring the possibility of joining the Laboratory staff. Please address Manager of Personnel, 10975 John Jay Hopkins Drive, San Diego 12, California.

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Robot repairman for a shipboard reactor

SPS Nuclear Division inspectors check performance of automatic welder destined for service aboard nuclear-powered ship. Machine—designed to reach virtually inaccessible components of reactor vessel closure head—produces a flawless, carbon-free weld, assuring an extremely reliable joint.

Typically, the closure head of a shipboard reactor is studded with the breech ends of half a hundred large cylindrical housings—spaced only inches apart. Penetrating the reactor, they carry the control rods, the instrumentation packages, or, in the larger diameters, provide core access. But whatever its function, each is stopped with a threaded plug—seated flush—or motor tube and welded all around the joint. And that is the problem. If it becomes necessary to remove a plug and later reinstall it, there is usually not enough elbow room for a man to get at it with a cutting tool or weld rod.

SPS helped its customer solve this problem by building two unique machines that can be lowered from the overhead and seated directly on top of the plug. The first machine automatically cuts through the old weld bead, provides for removal of chips, and then redresses the weld lip. The second (illustrated) automatically welds the reinstalled plug in place, supplying an argon-helium atmosphere that eliminates possible carbon deposition.

Apparatus like this gives you an excellent measure of SPS capabilities both in reactor components themselves and in specialized servicing equipment. If you have requirements in this field, contact SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium. Request Bulletin 2499.

NUCLEAR COMPONENTS Division

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The burning question of cool flames

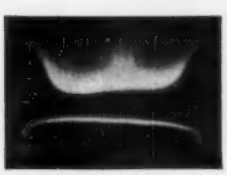
Between the brief stage of not burning and burning, many hydrocarbons react with oxygen at temperatures well below that of normal flame combustion. But the reactions are usually transient and hard to analyze. At the General Motors Research Laboratories, we have been able to investigate the *effect of chemical additives on cool preflames.*

To do this, the almost invisible cool flames are stabilized for hours in a flat-flame burner, permitting careful examination of the retardation or acceleration effects of the additives. From more than twenty additives studied, experimental results indicate that some chemicals affect combustion through the mechanism of preflame reactions. We are now accumulating new information on these additives' mode of operation. For instance: emission spectra support the conclusion that tetraethyl lead reacts with the oxygenated compounds formed in cool flames to yield lead oxide vapor. These findings of when and how lead oxide is formed are important in resolving a current controversy of science — the combustion behavior of tetraethyl lead.

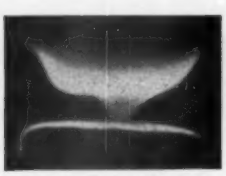
Studies such as this may lead to more economical and effective means of controlling unrestrained combustion — such as "knock" in reciprocating engines. The work is typical of GM Research's effort to provide useful information for a moving America. And in this way continue to keep our promise of "More and better things for more people."

General Motors Research Laboratories

Warren, Michigan



Iron carbonyl, an antiknock



Ethyl nitrate, a proknock

Iron carbonyl retards, ethyl nitrate accelerates central portion of cool flames.

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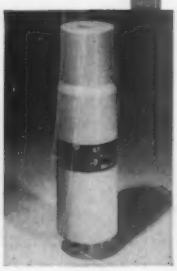

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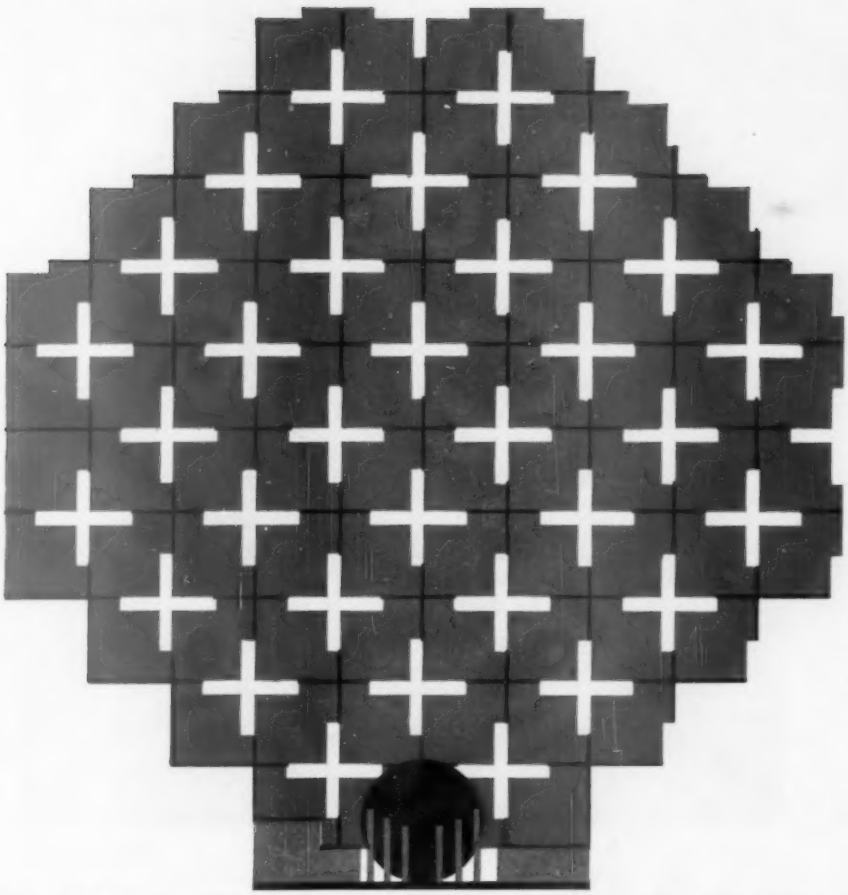

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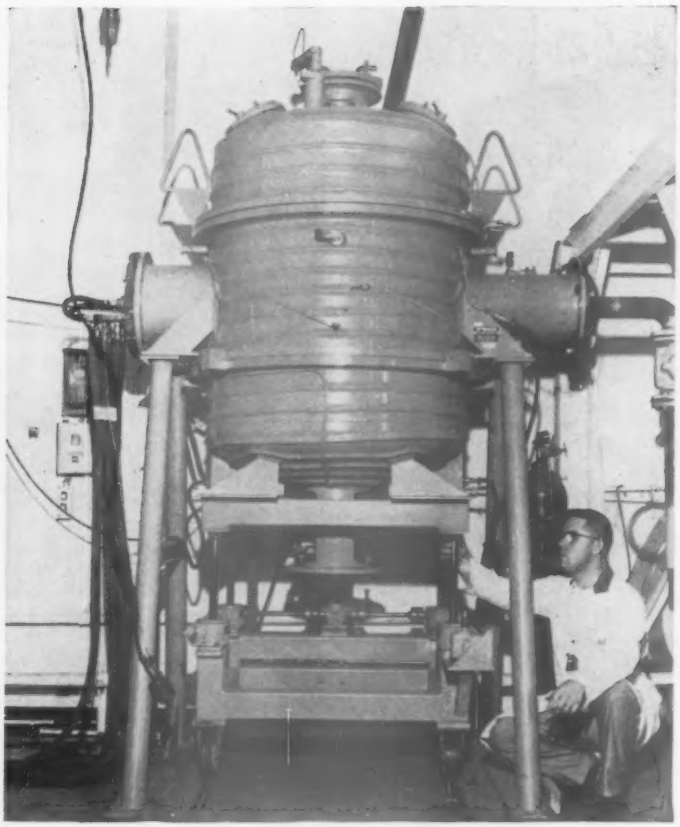

Installed at Atomics International, Canoga Park, California, Stokes 50KW vacuum furnace is accomplishing diverse and unusual melting and casting tasks.

Photograph courtesy of Atomics International, a division of North American Aviation, Inc.

How a Stokes vacuum furnace handles tough nuclear assignments . . .

There's practically no margin for error in melting and casting uranium for reactor fuel. For the exceptional precision and unusual versatility of equipment demanded in this application, Atomics International, a division of North American Aviation, Inc., installed a Stokes 50KW vacuum casting furnace.

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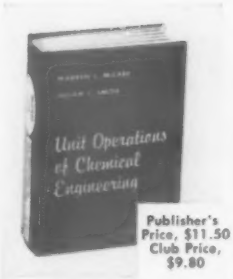

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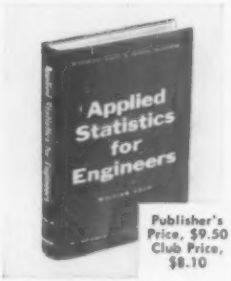

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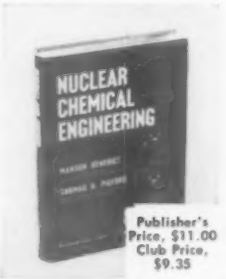

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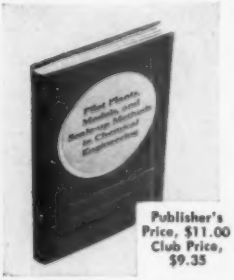

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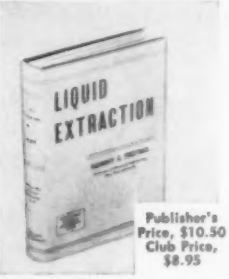

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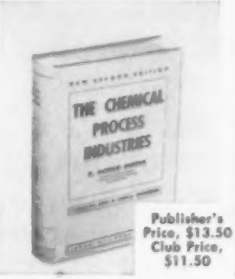

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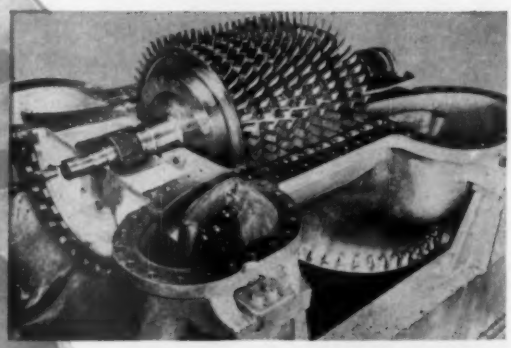
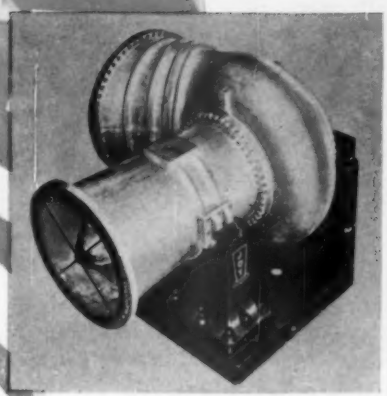


15,000 hp multi-stage axial flow compressor.



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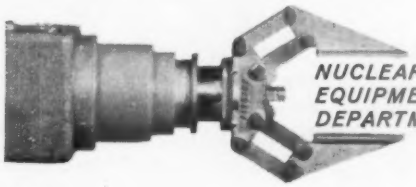

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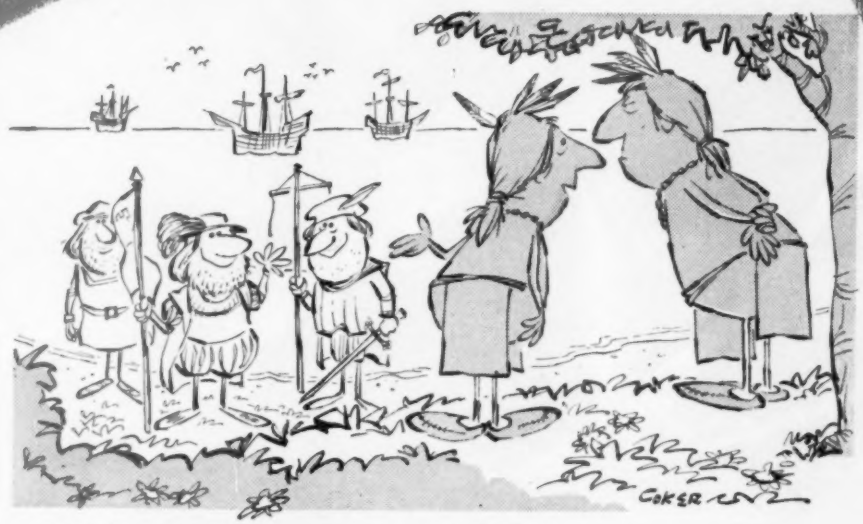

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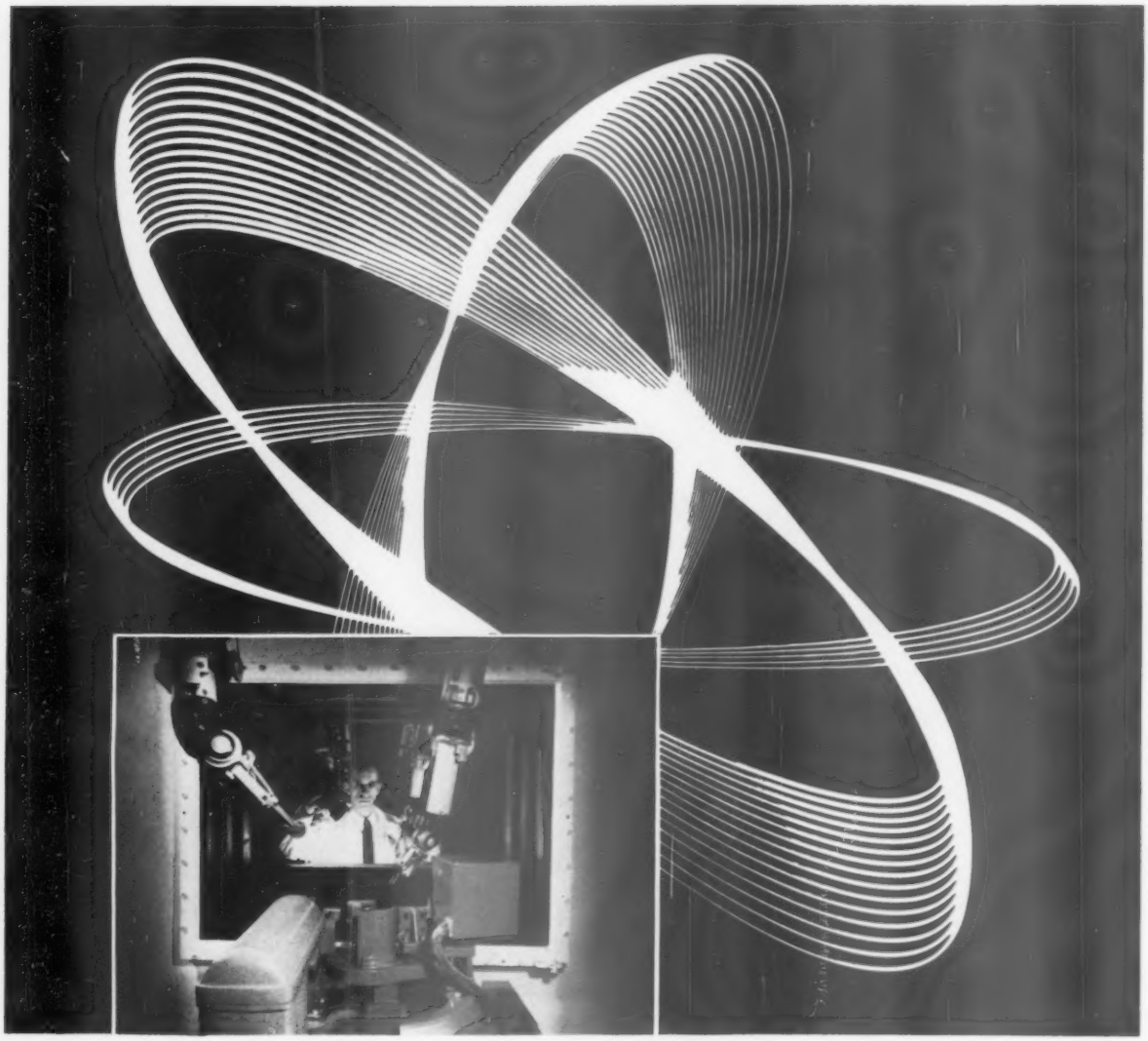

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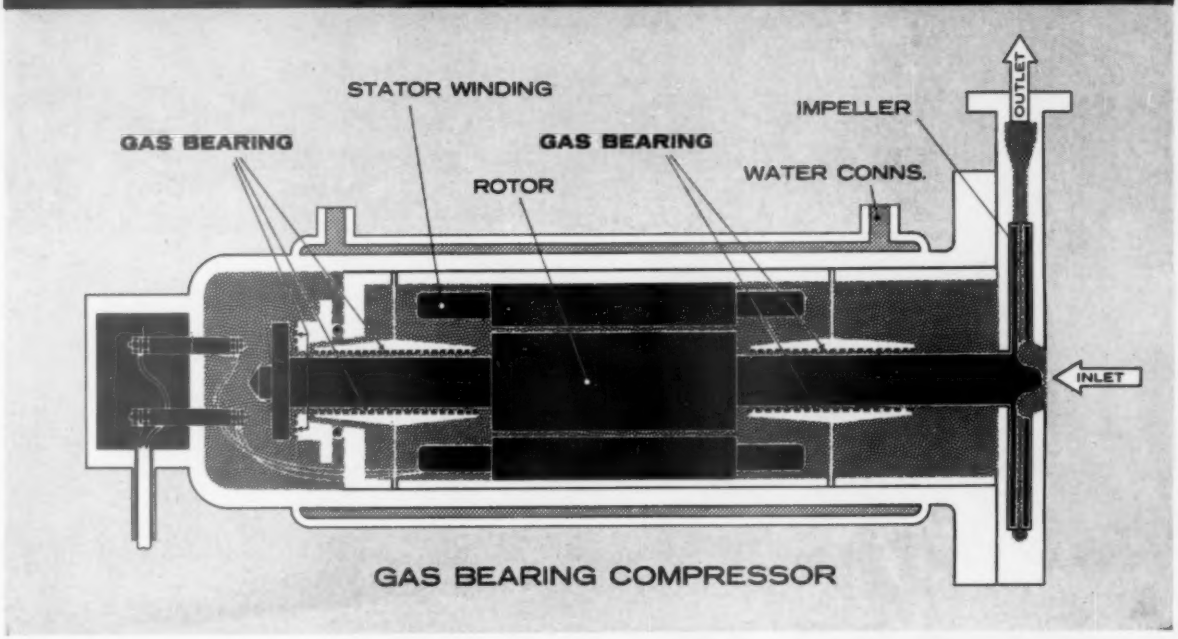

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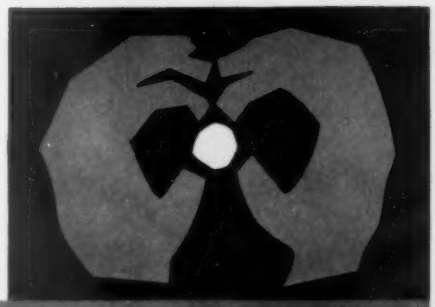

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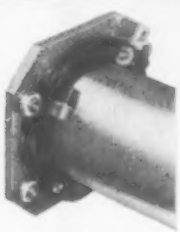
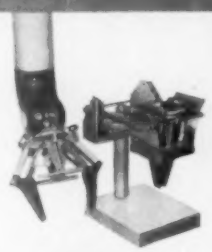


Improved *roller mount:* More rugged, more serviceable, less wear on through tube.



Improved *wrist joint, tong,* and *tong jig:* Greater protection of gears, more rugged, easier interchange.

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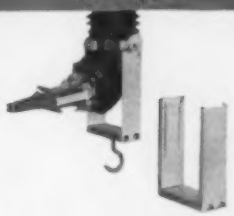
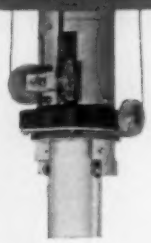


Improved *booting* and *load hook: Partial or* complete booting possible, load hook fits on booted or unbooted arm.



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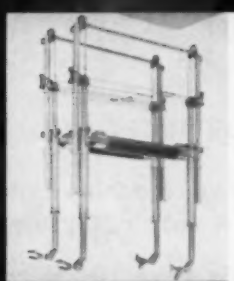

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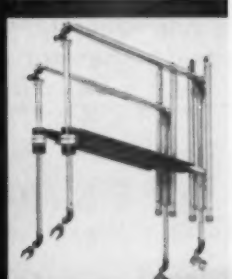

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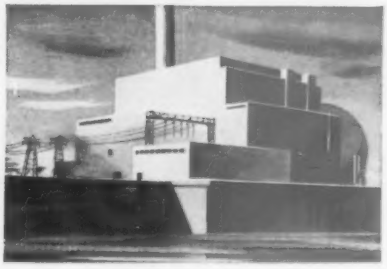

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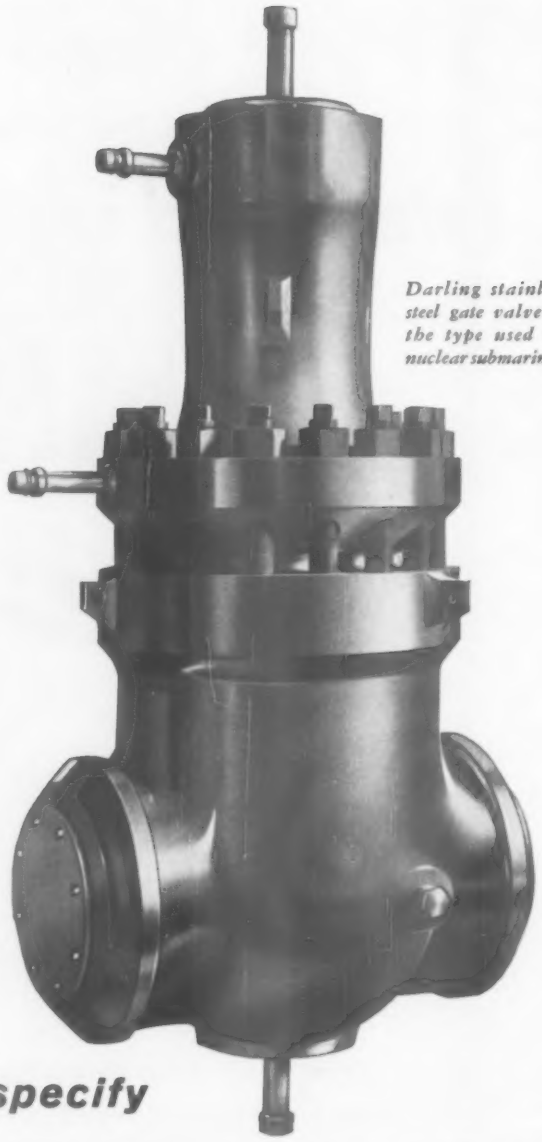

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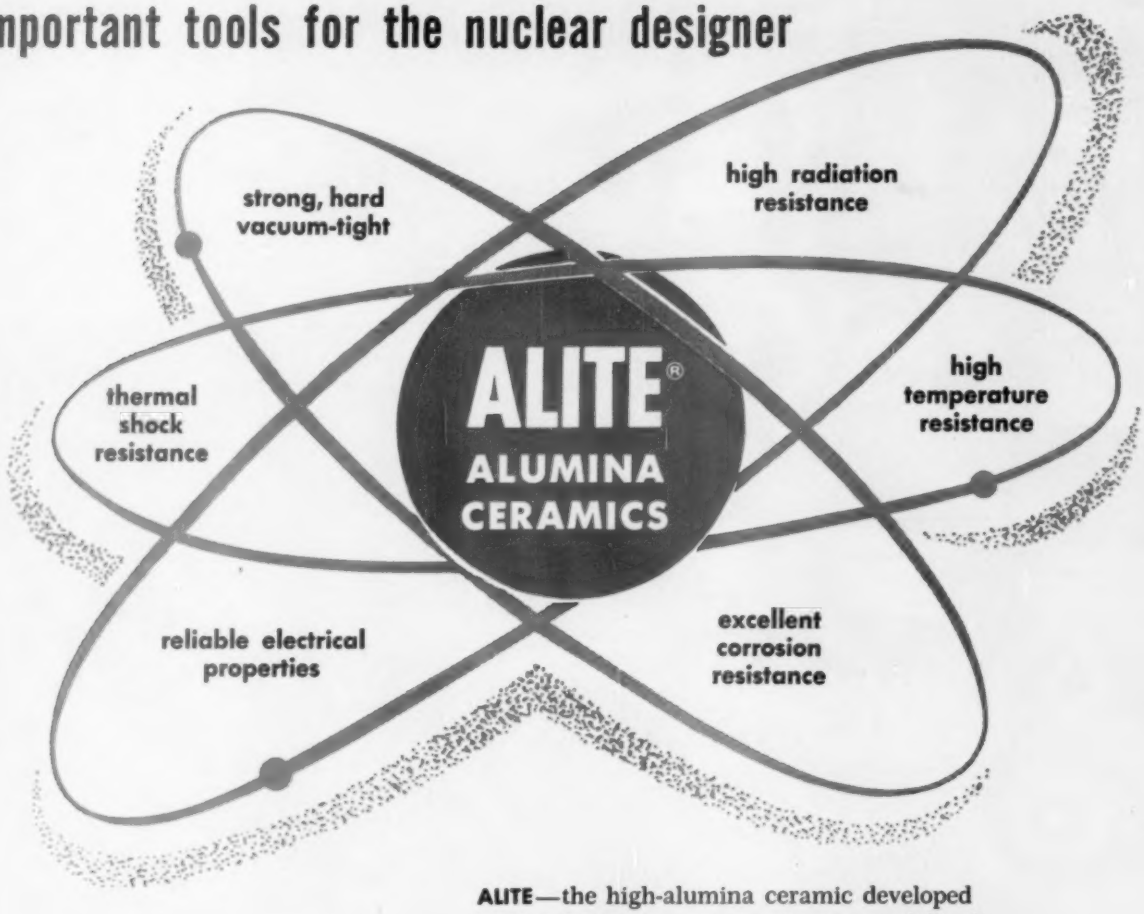

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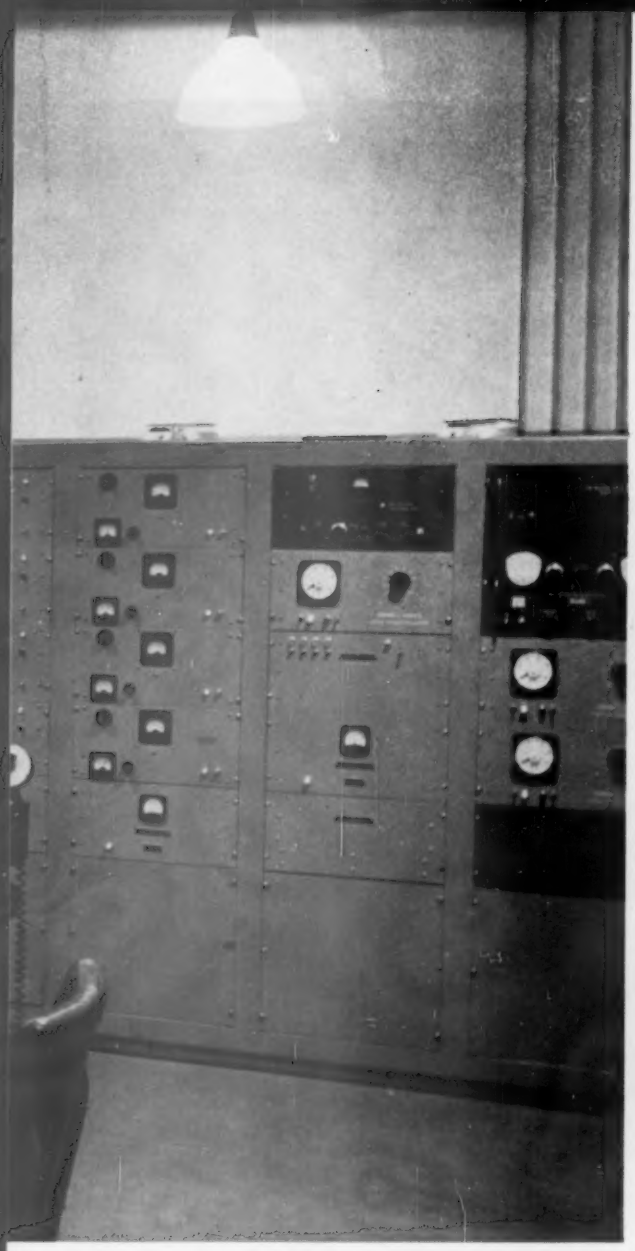

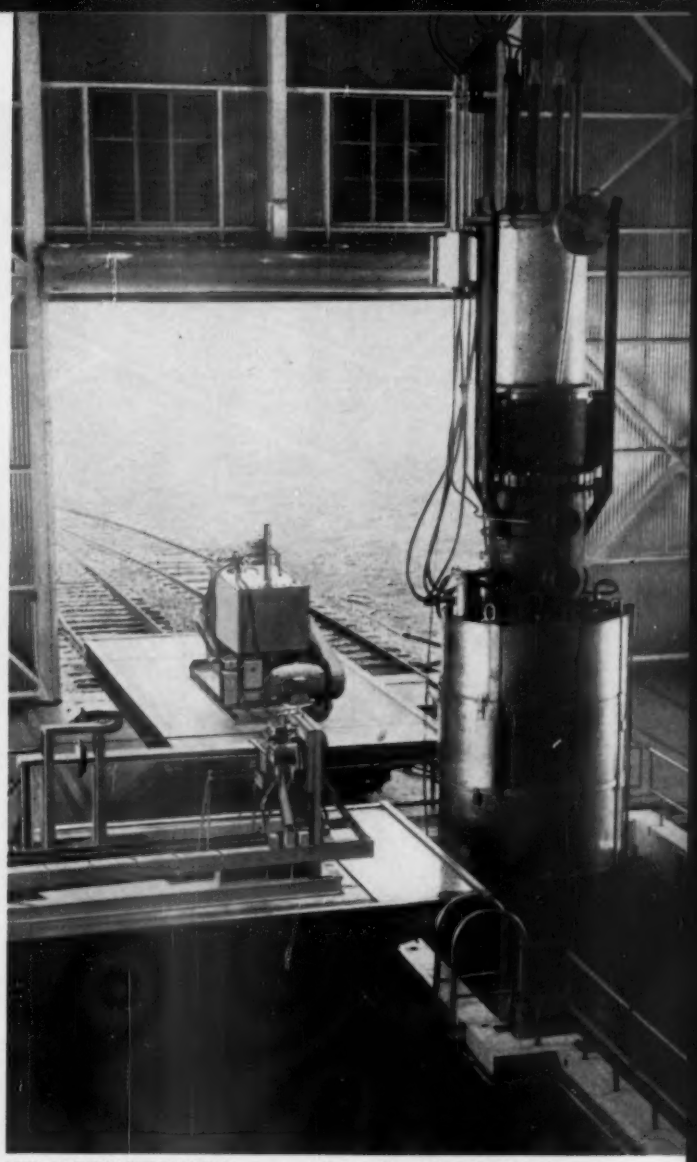

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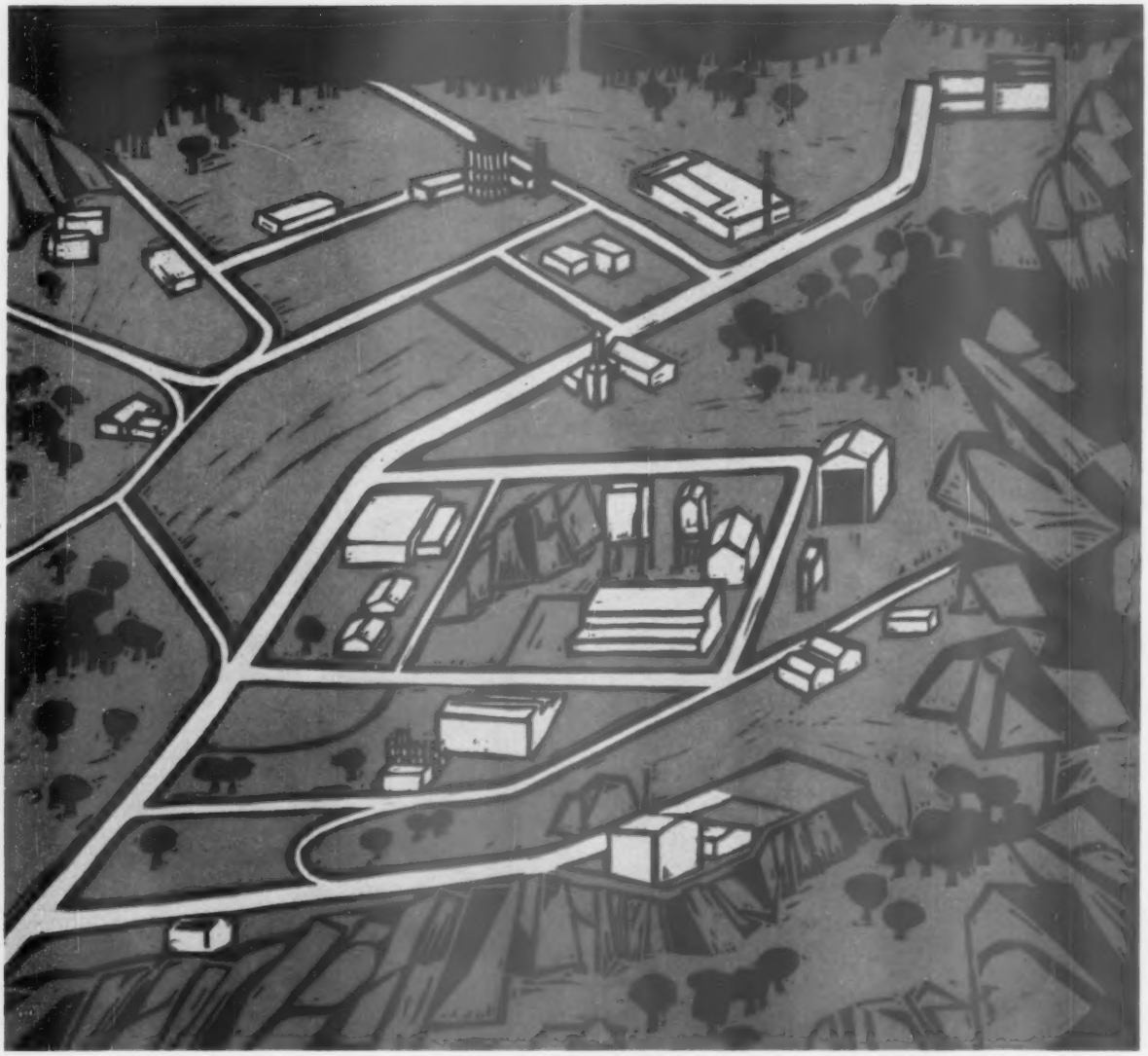
NEW OPPORTUNITIES FOR SCIENTIFIC AND PROFESSIONAL PERSONNEL:

Electro-mechanical • servo-mechanisms • nuclear reactor design modification • mechanical/hydraulic/pneumatic systems • theoretical nuclear physics • electrical/electronic reactor controls and instrumentation • electronic systems research and development • nuclear reactor technology • nuclear weapons effects analyses • aircraft and missiles systems reliability in a nuclear environment • cryogenic testing • metallurgy and nuclear physics. If you have experience and training in the above fields, you are invited to write: Dr. J. C. Flack, 834 W. Peachtree St., N.W., Atlanta, Georgia.

LOCKHEED NUCLEAR PRODUCTS

GEORGIA DIVISION: DAWSONVILLE, MARIETTA, ATLANTA

LOCKHEED



AI's extensive field laboratory is located in California's Santa Susana Mountains. *Woodcut by Edward Kysar.*

How can A.I. facilities help you plan a Nuclear Program?

In the picturesque Santa Susana mountains near Los Angeles, Atomics International has built an extensive field laboratory for research, engineering and testing in the nuclear sciences. Here, and at a headquarters complex in the valley below, men who pioneered the creative uses of atomic energy are applying their experience to develop advanced nuclear reactors and associated equipment.

Fourteen years of experience in developing various types of reactors for the Atomic Energy Commission and other organizations have given the men of Atomics International a collective background unparalleled in the industry. The facilities at their disposal are among the most sophisticated and extensive in the world.

Results of AI's work have been demonstrated in projects for the AEC which include the Organic Moderated Reactor Experiment at the National Reactor Testing Station in Idaho and the Sodium Reactor Experiment at the company's field laboratory. Additionally, AI built and is operating SNAP II, a 220 pound prototype reactor to produce three kilowatts of electricity for space vehicles.

Atomics International is also building large power reactors for electric utilities in Ohio and Nebraska under AEC programs. Studies are underway for other power reactors in the United States and Europe. Research reactors have been built by AI for Denmark, Germany, Italy, Japan, Puerto Rico and several sites in the United States.

For details contact: ATOMICS INTERNATIONAL, Canoga Park, California, U.S.A. Cable address: ATOMICS.

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN AVIATION, INC.

PIONEERS IN THE CREATIVE USE OF THE ATOM

Other offices in: Washington, D.C., U.S.A.; Geneva, Switzerland. Affiliated with: INTERATOM, Bensberg/Cologne, Federal Republic of Germany and DYNATOM, Paris, France.

B-L-H fabricates 30,000 psi vessel

This pressure vessel—believed to be the largest ever built—is one more indication of B-L-H's ability to handle huge and unwieldy jobs efficiently.

The assembled vessel, consisting of a high-pressure container moving in and out of a rigid frame made of six laminated steel plates each 4 in. thick, weighs 474,000 lb. and stands 35 ft. 1¼ in. high.

Designed by Baldwin-Lima-Hamilton for the United States government, this unusual piece of equipment was built to withstand the tremendous operational pressure of 30,000 psi and a test pressure of 45,000 psi. The super-strength bronze sealing retaining rings so essential to successful performance under these extreme pressures were manufactured and machined in the Industrial Equipment Division foundry.

Testing of this vessel, also done at Eddystone, required an elaborate procedure comparable in precision to the observation of a patient's heart during a surgical operation. More than 80 SR-4® strain gages, products of B-L-H's E&I Division, were located at all critical points of the structure. Over 1500 readings were taken of the strains and stresses developed during loading the vessel up to 45,000 psi and down again. Evaluation of all test results and a full year of normal operation proved that the numerous parts and materials behaved even better than anticipated.

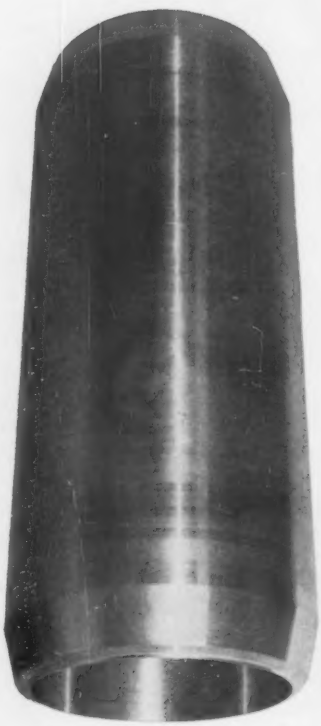
Our illustrated Weldment Bulletin 7001 will give you an excellent idea of our vast fabricating facilities. A copy is yours for the asking.

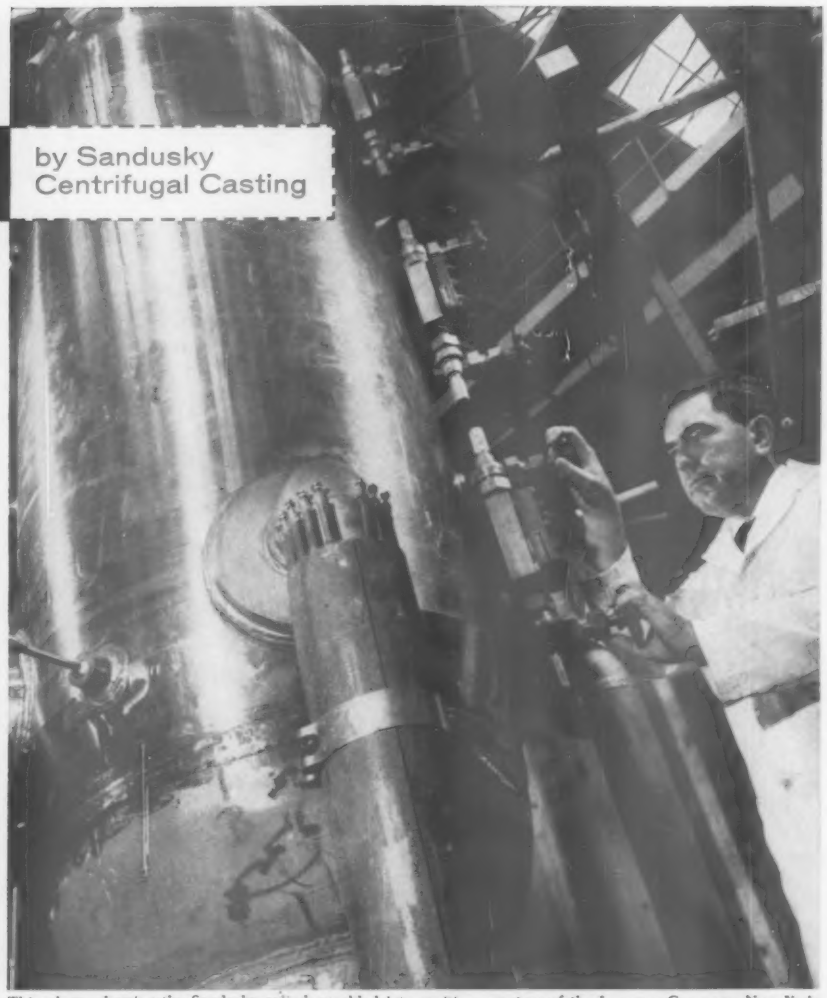
View of high-pressure vessel fabricated at Eddystone showing pressure cylinder withdrawn for loading

BALDWIN · LIMA · HAMILTON

Industrial Equipment Division · Philadelphia 42, Pa.

SOLVED: by Sandusky Centrifugal Casting





This photo, showing the Sandusky cylinder welded into position, courtesy of the Lummus Company, New York. New York who fabricated, assembled and tested the completed loop before shipping it to the ETR site in Idaho.

Nuclear Test Loop Uses Sandusky Centrifugal Casting as Pressurizer Cylinder

A Sandusky Centrifugal Casting is the main cylindrical component of an electrically heated pressurizer, designed by Knolls Atomic Power Laboratory to Section VIII, of the ASME Code (Unfired Pressure Vessels) for use in the new Engineering Test Reactor facilities at Idaho Falls, Idaho.

This 66¾" long cylinder, 27" O.D. with walls 2½" thick, was centrifugally cast of an 18-8 stainless steel (SA-351, Grade CF-8) for the extra corrosion resistance required under nuclear loop service conditions: demineralized water at temperatures to 650°F and pressures to 2500 PSI.

O. G. Kelley Co., Boston, to whom we delivered this 2-ton, fully machined cylinder, welded on the forged heads and nozzles, radiographed the welds, and hydro tested the completed vessel to 4300 PSI.

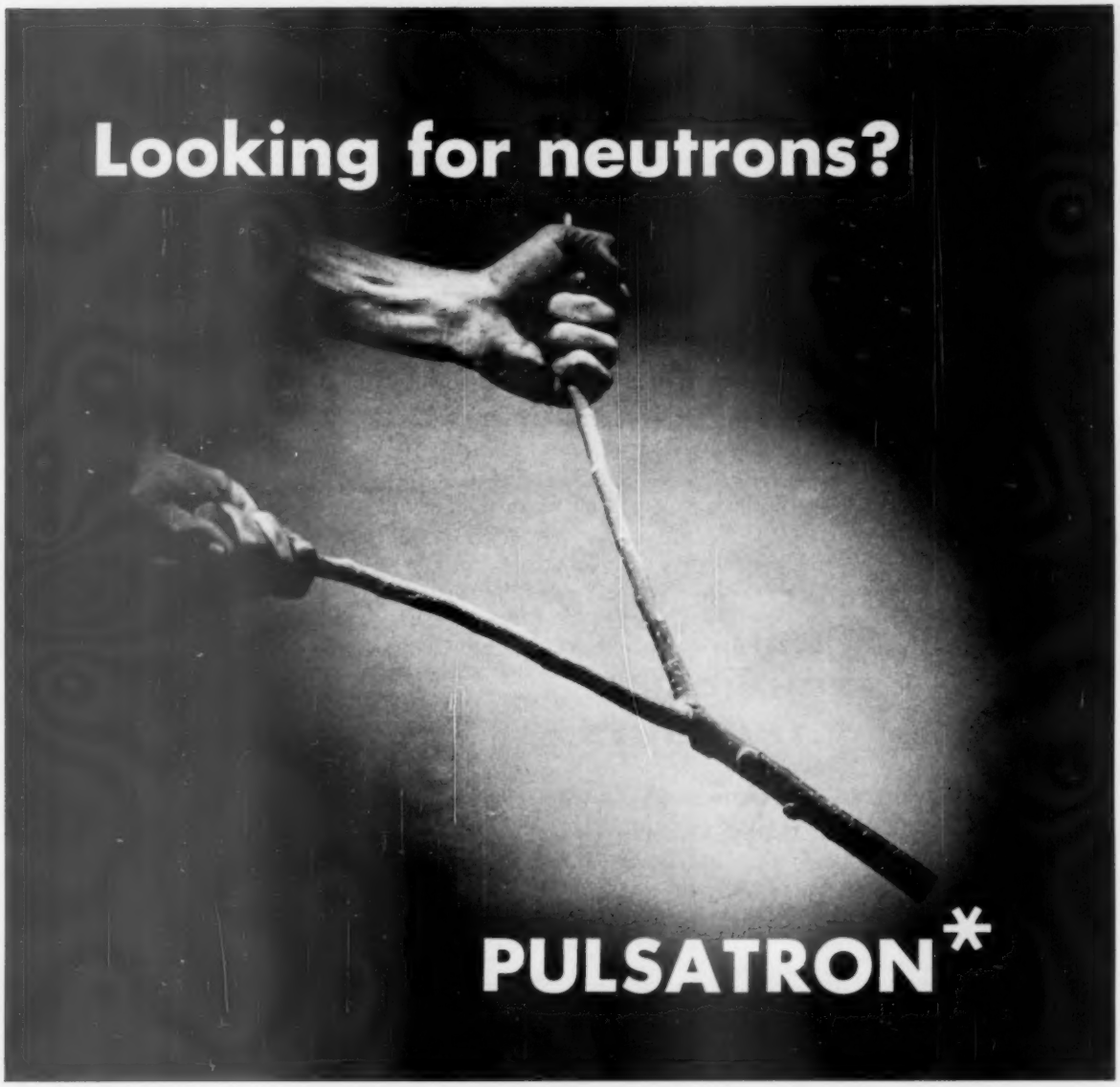
This is another example of the adaptability of Sandusky Centrifugal Castings to applications demanding the highest order of quality. They may well offer you a practical and economical answer to your cylindrical needs, also.

We are producing cylinders and piping in diameters from 7" to 54"—in lengths to 33 ft.—in a wide range of ferrous and non-ferrous alloys. Write for Bulletin 300, for more complete technical information on the Sandusky process and product application data.

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

Looking for neutrons?

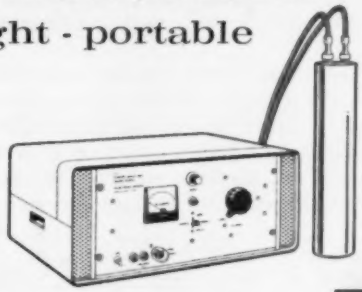


PULSATRON*

* the Kaman neutron source

small - lightweight - portable

10^7 neutron/pulse - nominal.
5 microseconds — pulse length.
Adjustable - 1-10 pulses/sec.
H^3 (d, n) He^4 reaction.
Accelerator Unit — 4" OD x 18" long.
Control Unit — 21¾" x 15¼" x 10½"



See the NT-60-8
operate at
1960 Atomic Exposition
New York Coliseum,
April 4 to 7, Booth 448

The NT-60-8 Pulsed Neutron Generator Assembly . . . *an Exclusive Development by*

KAMAN NUCLEAR
COLORADO SPRINGS, COLORADO
A Division of the Kaman Aircraft Corporation

Research and Development in Nuclear Weaponry and Instrumentation.

Scientists and Engineers . . . Live and Work in the fabulous Garden of the Gods vacationland. Write Employment Division 13

on behavior... The operator of one of the first production models of our 110 systems returned to his lab one Monday morning to find that the analyzer had printed readout on paper tape continuously for three days. "Faulty, bug-filled instrument", was his accusation. "Human error", our engineers replied. The operator in his haste had called for a preset count *and* non-destructive readout. The obedient instrument just printed and printed readout without destroying it. This is why we hasten to point out that our instruments are instructed not to reason why... not to second-guess... to just do what they're told. When you use a "110" you can be sure it will do exactly as you tell it.

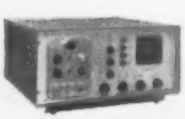
"*cramming*" *parts*... We discovered just in time that it is possible to go too far with this "compactness" business — to the point of defeating the purpose of the design. Some circuit boards have so many components on them they begin to look like popcorn balls. They're miserable to repair and cost a small fortune to replace. In our 110 Analyzer, we fought the initial urge to cram all parts on two or three boards. By using a few more, with fewer parts on each, we've made repairs easy, total replacement costs much lower — and the little extra space required isn't worth mentioning.

NON-TECHNICAL THOUGHTS...

about the TMC Portable 256-channel Pulse Analyzer

pricing... We have set prices on our instruments that we think are reasonable — not so that we can cut them just for underselling purposes. Price wars and bargains are for department stores. We'll stick to our guns because we're confident about our products.

These are 3 of the "110's" characteristics that have pleased the people who are now using the system. For complete summary of all the virtues of the analyzer, its plug-in logic units and data handling unit, see our new 6-page folder. Besides the usual advantages of transistor circuits (low heat, bench-top size, etc.) the 110 has several unique characteristics which are also prominently mentioned. A copy is yours on request.



If you're a Transistor Design Engineer and you're restless, we'd like to talk with you. The "110" is typical of the transistor instruments we are now working on.

TMC

TECHNICAL MEASUREMENT CORPORATION
441 Washington Ave., North Haven, Connecticut

NEW YORK COLISEUM / APRIL 4-7, 1960

OFFICIAL DIRECTORY OF EXHIBITORS

6th INTERNATIONAL ATOMIC EXPOSITION

The New York Coliseum is the site of the 6th International Atomic Exposition and all activities of the 1960 Nuclear Congress. The Congress, sponsored by the Engineers Joint Council, is supported by 28 engineering and scientific organizations and its program includes 57 technical papers specifically solicited to cover reactors, reactor design, materials and components, nuclear standards and isotopes and radiation processing. A meeting digest appears on the last page of this directory.

The Atomic Exposition enables over 120 companies including 14 French and 17 Canadian exhibitors, to display their latest products and services before the nuclear world. In this official directory of the Exposition the exhibitors are listed alphabetically. When read horizontally, the entry for each company shows the booth number and products and services exhibited. By scanning the appropriate vertical column, all companies featuring a particular type of product or service can be identified. Further detail is available in exhibitor advertising in this the March issue of NUCLEONICS; page numbers of such ads follow booth numbers. Locations of exhibits by booth number and a floor diagram are shown on the center spread of this directory.

EXPOSITION **SCHEDULE**

Tickets are on sale at registration desks in the New York Coliseum during show hours. Registration desks will require presentation of proper business credentials.

Monday, April 4.....11 a.m. to 5 p.m.
Tuesday, April 5..... 9 a.m. to 5 p.m.
Wednesday, April 6..... 9 a.m. to 5 p.m.
Thursday, April 7..... 9 a.m. to 5 p.m.

EXHIBITOR:	BOOTH NUMBER	AD PAGE, MARCH 1960 NUCLEONICS	INSTRUMENTS					REACTORS & COMPONENTS					NUCLEAR SERVICES					MISCELLANEOUS PRODUCTS								
			Components	Detection & Monitoring	Electronic	Process	Reactor Control	Components	Control Mechanisms	Reactors	Materials	Fuels	Computing	Irradiation	Metallurgical R & D	Nuclear Engineering	Other (See Footnote)	Books & Publications	Computers	Gloves, Glove Boxes, Hoods	Hot-Cell & Remote Equipment	Isotope Gages & Devices	Isotopes & Sources	Laboratory Apparatus	Shielding Materials	Other (See Footnote)
AMF Atomics Div. American Machine & Foundry Co. 140 Greenwich Ave. Greenwich, Conn.	526-30	109							✓	✓	✓	✓		✓		✓	1				✓	✓				
Ad-O-Plastic 240 Amboy Ave. Woodbridge, N. J.	641																									2
Aeroquip Corp. Marman Div. 11214 Exposition Blvd. Los Angeles 64, Calif.	524				✓			✓																		
Aetna Casualty & Surety Co. 151 Farmington Ave. Hartford 15, Conn.	548																3									
Allis-Chalmers Manufacturing Co. P. O. Box 512 Milwaukee 1, Wis.	212-16	18-19					✓	✓	✓	✓	✓					✓						✓				4
American Potash & Chemical Corp. See Lindsay Chemical Div.	506	162																								
Anton Electronic Laboratories 1226 Flushing Ave. Brooklyn 37, N. Y.	625	98	✓	✓	✓																	✓	✓			
Assembly Products, Inc. 75 Wilson Mills Rd. Chesterland, Ohio	645			✓	✓		✓																			
Atomics International Div. North American Aviation, Inc. P. O. Box 309 Canoga Park, Calif.	430-34	68 112-13								✓		✓				✓	5									
BJ Electronics Borg Warner Corp. 3300 Newport Blvd. Santa Ana, Calif.	331-35		✓	✓	✓	✓	✓																			
Bendix Aviation Corp. **Bendix Products Div.** 401 N. Bendix Drive South Bend 20, Ind.	527-35								✓																	
Cincinnati Div. Cincinnati, Ohio	527-35	161		✓	✓				✓																	
Computer Div. 5630 Arbor Vitae St. Los Angeles, Calif.	527-35											✓						✓								
The Beryllium Corp. P. O. Box 1462 Reading, Penna.	638-40										✓			✓												
Borg Warner Corp. See BJ Electronics Byron Jackson Pumps, Inc. Marvel-Schebler Products Div.	331-35																									
The Brush Beryllium Co. 5209 Euclid Ave. Cleveland 3, Ohio	204-06										✓			✓												
Burroughs Corp. Electro Data Div. 460 Sierra Madre Villa Pasadena, Calif.	239											✓						✓								

1 Waste-disposal service & systems 2 Plastic signs 3 Nuclear safety engineering 4 Accelerators
5 Nuclear field laboratory

EXHIBITOR:	BOOTH NUMBER	AD PAGE, MARCH 1960 NUCLEONICS	INSTRUMENTS					REACTORS & COMPONENTS					NUCLEAR SERVICES					MISCELLANEOUS PRODUCTS								
			Components	Detection & Monitoring	Electronic	Process	Reactor Control	Components	Control Mechanisms	Reactors	Materials	Fuels	Computing	Irradiation	Metallurgical R & D	Nuclear Engineering	Other (See Footnote)	Books & Publications	Computers	Gloves, Glove Boxes, Heads	Hot-Cell & Remote Equipment	Isotope Gages & Devices	Isotopes & Sources	Laboratory Apparatus	Shielding Materials	Other (See Footnote)
Byron Jackson Pumps, Inc. Borg Warner Corp. 2300 E. Vernon Ave. Los Angeles 54, Calif.	331-35							✓																		
CANADIAN EXHIBITORS	501-17 600-16																									
AMF Atomics Ltd. Port Hope, Ontario											✓															
Atomic Energy of Canada Ltd. Commercial Products Div. P. O. Box 711 Ottawa, Ontario		14,63																			✓	✓				
B. D. Bohna & Co. Ltd. 1070 Hornby St. Vancouver 9, B. C.										✓						✓										
Canadian Engineering Co Ltd. Shell Tower Building Montreal, Quebec																✓										
Canadian General Electric Co. Ltd. 107 Park St. Peterborough, Ontario										✓	✓					✓										
Canadian Westinghouse Co. Ltd. 286 Sanford Ave. North Hamilton, Ontario										✓						✓										
Consolidated Denison Mines Ltd. 360 Bay St. Toronto 1, Ontario											✓															
Eldorado Mining & Refining Ltd. Port Hope, Ontario											✓															
Electronic Associates Ltd. 4616 Yonge St. Willowdale, Ontario				✓	✓																✓					
Gunnar Mines Ltd. 25 Adelaide St. West Toronto 1, Ontario											✓															
Merck & Co. Ltd. P. O. Box 899 Montreal 3, Quebec																						✓				
Nuclear Enterprises Ltd. 1750 Pembina Highway Winnipeg 9, Manitoba		163		✓	✓																					
Ontario Research Foundation 43 Queen's Park Toronto 5, Ontario																✓										
Orenda Engines Ltd. Box 4015, Terminal "A" Toronto 1, Ontario								✓		✓						✓										
Samia Inspection Co. 280 Tecumseh St. Samia, Ontario																	1									
Sorel Industries Ltd. 1405 Peel St. Montreal, Quebec								✓																		
Velan Engineering Ltd. 2124 Ward Ave. Ville St. Laurent Montreal 9, Quebec								✓																		

1 Radiographic inspection

EXHIBITOR:	BOOTH NUMBER	AD PAGE, MARCH 1960 NUCLEONICS	INSTRUMENTS					REACTORS & COMPONENTS						NUCLEAR SERVICES					MISCELLANEOUS PRODUCTS							
			Components	Detection & Monitoring	Electronic	Process	Reactor Control	Components	Control Mechanisms	Reactors	Materials	Fuels	Computing	Irradiation	Metallurgical R & D	Nuclear Engineering	Other (See Footnote)	Books & Publications	Computers	Gloves, Glove Boxes, Hoods	Hot-Cell & Remote Equipment	Isotope Gages & Devices	Isotopes & Sources	Laboratory Apparatus	Shielding Materials	Other (See Footnote)
Cambridge Filter Corp. P. O. Box 1255 Syracuse 1, N. Y.	325																									5
Central Research Laboratories, Inc. Red Wing, Minn.	621	61																			✓					
Charleston Rubber Co. Stark Industrial Park Charleston, S. C.	306	174																		✓						
Combustion Engineering, Inc. 200 Madison Ave. New York 16, N. Y.	649-50			✓				✓	✓	✓	✓	✓	✓			✓	1								✓	
Conference Book Service 3209 Columbia Pike Arlington 4, Va.	248																	✓								
Consolidated Controls Corp. Durant Ave. Bethel, Conn.	534		✓	✓	✓	✓	✓															✓				2
Consolidated Siphon Supply Co., Inc. Terriss Div. 22 Wooster St. New York 13, N. Y.	308							✓										✓			✓			✓		
Consultants Bureau Enterprises, Inc. 227 West 14th St. New York 11, N. Y.	607																	✓								
Controlled Atmosphere Enclosures Jacksonville 6, Fla.	334	140																		✓	✓					
Controls for Radiation, Inc. 130 Alewife Brook Parkway Cambridge, Mass.	632	155		✓	✓											✓	1 3									
Cooper Metallurgical Associates Box 3991 Cleveland 20, Ohio	605										✓				✓											
Crossroads Marine Disposal Corp. 26 T Wharf Boston, Mass.	226																1									
Damascus Tube Co. Greenville, Penna.	240							✓			✓				✓											
The Daven Co. Route No. 10 Livingston, N. J.	327				✓			✓								✓										
Elcor Inc. 1225 W. Broad St. Falls Church, Va.	210	157	✓		✓																					
Encyclopaedia Britannica 551 Fifth Ave. New York, N. Y.	339																✓									
Erskine-Healy Inc. 420 St. Paul St. Rochester 5, N. Y.	609																			✓						
Flanders Filters Inc. P. O. Box 718 Riverhead, N. Y.	532																									4

1 Waste-disposal service & systems 2 Accelerators 3 Activation analysis 4 Particulate filters; air-purification units
5 Dust collectors; air purifiers and filters

EXHIBITOR:	BOOTH NUMBER	AD PAGE, MARCH 1960 NUCLEONICS	INSTRUMENTS					REACTORS & COMPONENTS					NUCLEAR SERVICES					MISCELLANEOUS PRODUCTS							
			Components	Detection & Monitoring	Electronic	Process	Reactor Control	Components	Control Mechanisms	Reactors	Materials	Fuels	Computing	Irradiation	Metallurgical R & D	Nuclear Engineering	Other (See Footnote)	Books & Publications	Computers	Gloves, Glove Boxes, Hoods	Hot-Cell & Remote Equipment	Isotope Gages & Devices	Isotopes & Sources	Laboratory Apparatus	Shielding Materials	Other (See Footnote)
Florida Development Commission Carlton Building — East Wing Tallahassee, Fla.	244																1								
Ford Instrument Co. 31-10 Thomson Ave. Long Island City 1, N. Y.	637				✓	✓	✓										2								
Foster Engineering Div. See Hammel-Dahl Div.	449-50																								
FRENCH EXHIBITORS	221-33 320-32	137																							
Appareils Gachot 179 Ave. de la Division Leclerc Enghien (S. & O.)					✓			✓															✓		
A. T. E. N 4, Rue de Teheran Paris 8																	3								
Caratom See Etablissement Kuhlmann/Simo			✓	✓	✓		✓		✓							✓				✓		✓			
Commissariat a l'Energie Atomique 69, Rue de Varenne Paris 7											✓			✓	✓							✓			
Compagnie de Saint-Gobain 62, Boulevard Victor-Hugo Neuilly S/Seine																				✓			✓		
Groupment Atomique Alsacienne Atlantique 100, Ave. Adouard Herriot le Plessis-Robinson										✓					✓	4									
Hispano-Suiza France Rue Guynemer Bois-Colombes					✓			✓												✓					
Etablissement Jahan 24, Rue des Gravilliers Paris 3																									
Etablissements Kuhlmann/Simo Caratom 25, Boulevard de l'Admiral Bruisc Paris 16											✓	✓		✓	✓							✓		✓	
Manufacture Francaise de Vide-Tauries Automatiques 169 Ave. Victor Hugo Paris 16								✓															✓		
Pechiney 23 Rue Balzac Paris 8		45						✓	✓		✓	✓			✓								✓		
Societe Alsacienne de Constructions Mechaniques 69, Rue de Monceau Paris 8				✓	✓																				
Societe Electrometallurgique de Planet 9, Rue Chauchat Paris 9																									5
Soc. Ind. de Combustible Nucleaire 69, Rue de Monceau Paris 8		119										✓													
Societe Industrielle d'Etudes et de Realisations Scientifiques 108 Ave. du Maine Paris 14								✓							✓					✓			✓		

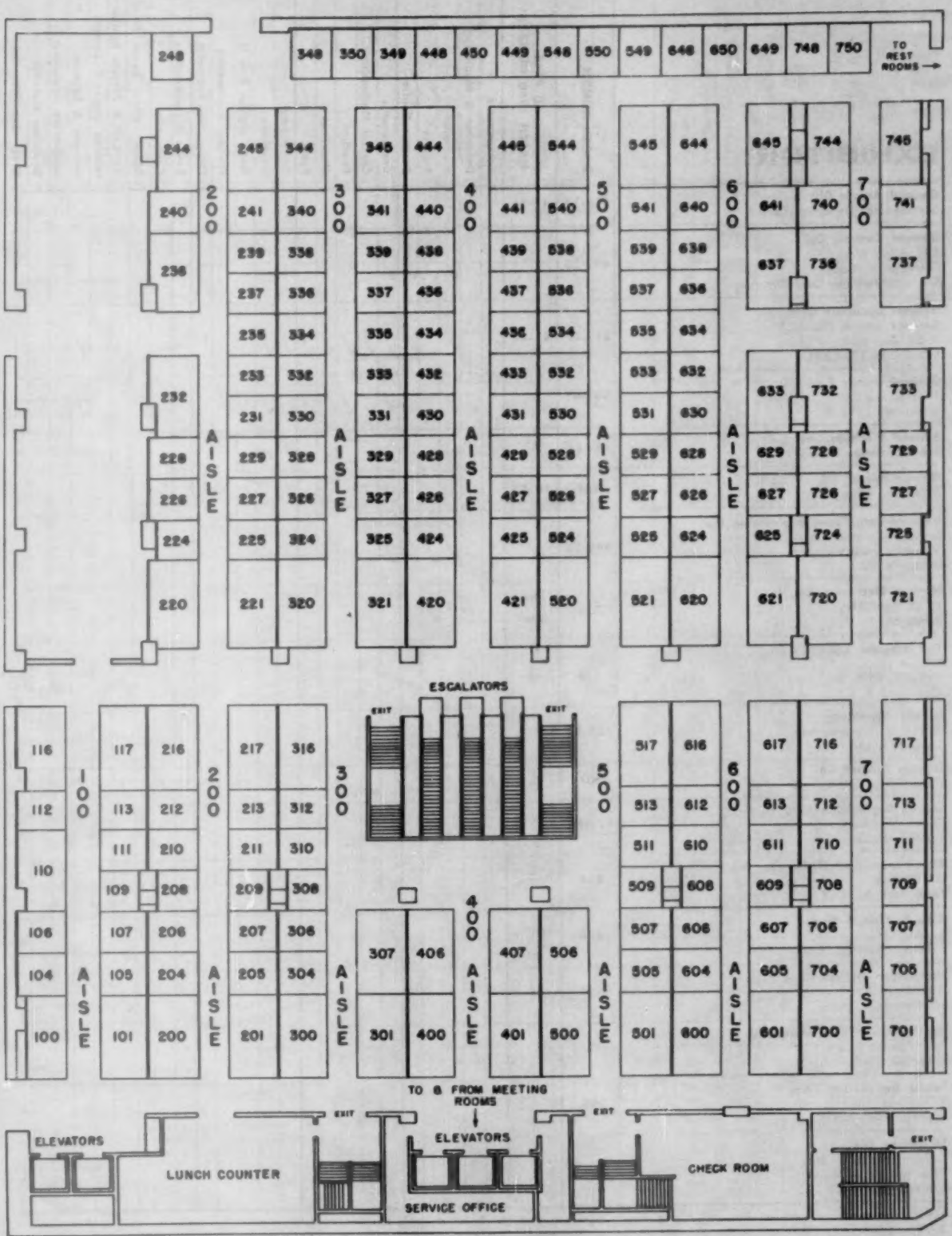
1 Nuclear-site services 2 Nuclear-ship conversion; direct-conversion developments
3 Information and public relations services 4 Architect-engineering 5 Metals

LOCATIONS OF EXHIBITS

SECOND FLOOR / NEW YORK COLISEUM

200	Wah Chang Corp.
201	Radiation Instrument Development Lab., Inc.
204,206	The Brush Beryllium Co.
205,207	Mobil Oil Co.
208	Lerma Engineering Corp.
209	Reuter-Stokes Electronic Components, Inc.
210	Elcor, Inc.
211	Pacific Coast Engineering Co.
212-216	Allis-Chalmers Manufacturing Co.
213	Research Equipment Co.
217	International Nickel Co., Inc.
220	Vard Inc.
221-233	**FRENCH EXHIBITORS**
320-332	Appareils Gachot A. T. E. N. Commissariat a l'Energie Atomique Compagnie de Saint-Gobain Groupment Atomique Alsacienne Atlantique Hispano-Suiza France Etablissement Jahan Etablissements Kuhlmann/Simo; Caratom Manufacture Franciase de Vide-Touries Pechiney Societe Alsacienne de Constructions Mecaniques Societe Electrometallurgique de Planet Societe Industrielle de Combustible Nucleaire Societe Industrielle d'Etudes et de Realisations Scientifiques
224	Pergamon Press, Inc.
226	Crossroads Marine Disposal Corp.
228	The Timken Roller Bearing Co.
235	D. Van Nostrand Co., Inc.
236	Technical Measurement Corp.
239	Burroughs Corp.
240	Damascus Tube Co.
244	Florida Development Commission
248	Conference Book Service
300-304	The Martin Co.
301	Technical Associates
306	Charleston Rubber Co.
307	Hughes Aircraft Co.
308	Consolidated Siphon Supply Co., Inc.
310	Radiation Counter Laboratories, Inc.
312	NUCLEONICS — A McGraw-Hill Publication
316	Vitro Corp. of America
321	The Victoreen Instrument Co.
325	Cambridge Filter Corp.
327	The Daven Co.
331-335	Borg-Warner Corp. BJ Electronics Byron Jackson Pumps Marvel-Schebler Products Div.
334	Controlled Atmosphere Enclosures
338	Hamner Electronics Co., Inc.
339	Encyclopaedia Britannica
340	Riggs Nucleonics Corp.
400-406	U. S. Steel Corp.
401	N. Y. State Atomic Energy Development Comm.
407	Mallinckrodt Chemical Works
420-424	Westinghouse Electric Corp.
421-431	Union Carbide Corp. Linde Co. National Carbon Co. Oak Ridge National Lab. Union Carbide Metals Co.
426	Landsverk Electrometer Co
430-434	North American Aviation, Inc.
433-435	Harvey Aluminum Co.
438	The Harshaw Chemical Co.
440	Lundell & Co.
441	The Griscom-Russell Co.
444	Nuclear Materials & Equipment Corp.
445	Teleflex, Inc.
448	Kaman Aircraft Co., Nuclear Div.
449,450	General Controls Co. Hammel-Dahl/Foster Engineering Div.
500	Nuclear Development Corp. of America
501-517	**CANADIAN EXHIBITORS**
600-616	AMF Atomics Ltd. Atomic Energy of Canada Ltd. B. D. Bohna & Co. Ltd. Canadian Engineering Co. Ltd. Canadian General Electric Co. Ltd. Canadian Westinghouse Co. Ltd. Consolidated Denison Mines Ltd. Eldorado Mining & Refining Ltd. Electronic Associates Ltd. Gunnar Mines Ltd. Merck & Co. Ltd. Nuclear Enterprises Ltd. Ontario Research Foundation Orenda Engines Ltd. Sarnia Inspection Co. Sorel Industries Ltd. Velan Engineering Ltd.
506	Lindsay Chemical Div.
520	M & C Nuclear, Inc.
521-525	Instron Engineering Corp.
524	Aeroquip Corp.
526-530	AMF Atomics
527-535	Bendix Aviation Corp.
532	Flanders Filters Inc.
534	Consolidated Controls Corp.
538-540	National Lead Co.
539	Permali, Inc.
541-545	General Electric Co.
544	Minneapolis-Honeywell Reg. Co.
548	Aetna Casualty & Surety Co.
550,549,648	Thompson-Ramo-Wooldridge Inc.
601	Lockheed Nuclear Products
605	Cooper Metallurgical Associates
607	Consultants Bureau, Inc.
609	Erskine Healy
611	North American Van Lines
613-617	General Dynamics Corp., General Atomic Div.
620	Tracerlab, Inc.
621	Central Research Lab., Inc.
624	Kollmorgen Optical Corp.
625	Anton Electronic Laboratories
626,628	The Marquardt Corp.
627	United Nations
629	U. S. Nuclear Corp.
630	RCA Service Co.
632	Controls for Radiation, Inc.
633	Nuclear Data, Inc.
634	Nuclear Measurement Corp.
637	Ford Instrument Co.
638,640	The Beryllium Corp.
641	Ad-O-Plastic
644	Librascope, Inc.
645	Assembly Products Inc.
649,650	Combustion Engineering, Inc.

AT THE ATOMIC EXPOSITION



EXHIBITOR:	BOOTH NUMBER	AD PAGE, MARCH 1960 NUCLEONICS	INSTRUMENTS					REACTORS & COMPONENTS						NUCLEAR SERVICES					MISCELLANEOUS PRODUCTS								
			Components	Detection & Monitoring	Electronic	Process	Reactor Control	Components	Control Mechanisms	Reactors	Materials	Fuels	Computing	Irradiation	Metallurgical R & D	Nuclear Engineering	Other (See Footnote)	Books & Publications	Computers	Gloves, Glove Boxes, Hoods	Hot-Cell & Remote Equipment	Isotope Gages & Devices	Isotopes & Sources	Laboratory Apparatus	Shielding Materials	Other (See Footnote)
General Atomic Div. See General Dynamics Corp.	613-17	41-44																								
General Controls Co. 801 Allen Ave. Glendale 1, Calif. See also Hammel-Dahl Div.	449-50				✓	✓	✓	✓																		
General Dynamics Corp. General Atomic Div. P. O. Box 608 San Diego 12, Calif.	613-17	41-44						✓	✓	✓	✓	✓	✓	✓			1			✓			✓			
General Electric Co. 1 River Rd. Schenectady, N. Y.	541-45			✓	✓			✓	✓	✓		✓		✓		✓							✓			
General Precision, Inc. See Librascope Div.	644																									
Griscom-Russell Co. Massillon, Ohio	441	38-39						✓																		
Hammel-Dahl/Foster Engineering Div. General Controls Co. Warwick Industrial Park Warwick, R. I.	449-50				✓	✓	✓	✓																		
Hamner Electronics Co., Inc. P. O. Box 531 Princeton, N. J.	338	2nd cover		✓	✓	✓	✓																			
The Harshaw Chemical Co. Crystal Div. 1945 E. 97th St. Cleveland 6, Ohio	438	48		✓																						2
Harvey Aluminum 19200 S. Western Ave. Torrance, Calif.	433-35							✓			✓				✓											
Hughes Aircraft Co. Culver City, Calif.	307		✓	✓	✓				✓	✓									✓		✓	✓	✓			
Instron Engineering Corp. 2500 Washington St. Canton, Mass.	521-25																							✓		
The International Nickel Co., Inc. 67 Wall St. New York 5, N. Y.	217							✓			✓				✓											3
Kaman Aircraft Corp. Nuclear Div. Colorado Springs, Colo.	448	71																								4
Kollmorgen Optical Corp. 347 King St. Northampton, Mass.	624	35																			✓					5
The Landsverk Electrometer Co. 641 Sonora Ave. Glendale 1, Calif.	426			✓	✓																					
Lerma Engineering Corp. P. O. Box 168 Northampton, Mass.	208							✓												✓						5
Librascope Div. General Precision, Inc. 808 Western Ave. Glendale 1., Calif.	644		✓				✓						✓						✓					✓		5

1 Hot cell services, scientific studies, fusion and direct conversion research 2 Optical and detection crystals
3 Welding equipment 4 Pulsed-neutron generator 5 Optical instruments

EXHIBITOR:	BOOTH NUMBER	AD PAGE, MARCH 1960 NUCLEONICS	INSTRUMENTS					REACTORS & COMPONENTS					NUCLEAR SERVICES					MISCELLANEOUS PRODUCTS								
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Linde Co. Div. Union Carbide Corp. 420 Lexington Ave. New York 17, N. Y.	421-31	156																				✓				1
Lindsay Chemical Div. American Potash & Chemical Corp. 99 Park Ave. New York 16, N. Y.	506	162																								2
Lockheed Nuclear Products 3272 Peachtree Road, N. E. Atlanta 5, Ga.	601	66-7							✓	✓	✓			✓		✓										
Lundell & Co. 7356 Wood Lawn Ave. Chicago 19, Ill.	440				✓	✓	✓																			
M & C Nuclear, Inc. Subsidiary of Texas Instruments Inc. P. O. Box 898 Attleboro, Mass.	520	2									✓	✓			✓							✓				
Mallinckrodt Nuclear Corp. 3600 North Second St. St. Louis, Mo.	407	49									✓	✓														
The Marquardt Corp. 16555 Saticoy St. Van Nuys, Calif.	626-28		✓	✓				✓	✓	✓			✓			✓										
The Martin Co. Nuclear Div. — G-3037 Baltimore 3, Md.	300-04	5 105								✓		✓														
Marvel-Schebler Products Div. Borg-Warner Corp. P. O. Box 863 Decatur, Ill.	331-35							✓	✓							✓										
McGraw-Hill Publishing Co. See NUCLEONICS	312	145																								
Minneapolis-Honeywell Regulator Co. Wayne & Windrim Aves. Philadelphia 44, Penna.	544	9-12	✓	✓	✓	✓	✓	✓										✓			✓		✓			
Mobil Oil Co. 150 E. 42nd St. New York, N.Y.	205-07															✓										3
National Carbon Co. Division of Union Carbide Corp. 30 East 42nd St. New York 17, N. Y.	421-31	4th cover						✓			✓	✓													✓	4
National Lead Co. 111 Broadway New York 6, N. Y.	538-40							✓			✓	✓							✓						✓	
New York State Atomic Energy Development Commission Albany, N. Y.	401																5									
North American Aviation, Inc. See Atomic International Div.	430-34	68 112-13																								
North American Van Lines, Inc. New Haven Ave. at Meyer Rd. Fort Wayne, Ind.	611																6									
Nuclear Data, Inc. 145 N. Washington St. Wheaton, Ill.	633		✓	✓	✓													✓				✓				

1 Rare gases 2 Chemicals, rare earths 3 Lubricants for power plants 4 Filters 5 Nuclear-site services
6 Transportation of high value, delicate equipment

EXHIBITOR:	BOOTH NUMBER	AD PAGE, MARCH 1960 NUCLEONICS	INSTRUMENTS					REACTORS & COMPONENTS						NUCLEAR SERVICES					MISCELLANEOUS PRODUCTS								
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Nuclear Development Corp. of America 5 New St. White Plains, N. Y.	500	20						✓	✓	✓		✓	✓	✓	✓	✓					✓				✓	
Nuclear Materials & Equipment Corp. Apollo, Penna.	444	110		✓							✓	✓				✓	1						✓	✓		
Nuclear Measurements Corp. 2460 N. Arlington Ave. Indianapolis 18, Ind.	634	104 146		✓	✓		✓																	✓		
NUCLEONICS — A McGraw-Hill Publication 330 West 42nd St. New York 36, N. Y.	312	145																✓								
Oak Ridge National Laboratory (Union Carbide Nuclear Corp.) P. O. Box X Oak Ridge, Tenn.	421-31														✓								✓			
Oerlikon Engineering Co. Zurich, Switzerland	341																									2
Pacific Coast Engineering Co. P. O. Drawer E Alameda, Calif.	211	13						✓		✓	✓					✓									✓	
Pergamon Press Inc. 122 East 55th St. New York 22, N. Y.	224	152																✓								
Permali, Inc. P. O. Box 718 Mount Pleasant, Penna.	539	7																							✓	
RCA Service Co. Cherry Hill, Delaware Township Camden 8, N. J.	630	159		✓													3									
Radiation Counter Laboratories, Inc. 5121 W. Grove St. Skokie, Ill.	310	33	✓	✓	✓																					
Radiation Instrument Development Lab., Inc. 5737 South Halsted St. Chicago 21, Ill.	201	91	✓	✓	✓																		✓			
Ray Proof Corp. Stamford, Conn.	500	60						✓																	✓	
Research Equipment Co. P. O. Box 127 Glen Ellyn, Ill.	213																			✓						
Reuter-Stokes Electronic Components, Inc. 2149 Hamilton Ave. Cleveland 14, Ohio	209		✓	✓	✓																					
Riggs Nucleonics Corp. 135 West Magnolia Blvd. Burbank, Calif.	340	166		✓	✓											✓										
Technical Associates 140 West Providencia Ave. Burbank, Calif.	301	117	✓	✓	✓																					
Technical Measurement Corp. 441 Washington Ave. North Haven, Conn.	236	72		✓	✓																					

1 Hot-cell decontamination, contaminated-garment laundry services 2 Quadrupole focusing magnet, magnets
3 Health physics, instrument installation & maintenance services

EXHIBITOR:	BOOTH NUMBER	AD PAGE, MARCH 1960 NUCLEONICS	INSTRUMENTS					REACTORS & COMPONENTS					NUCLEAR SERVICES					MISCELLANEOUS PRODUCTS								
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Teleflex Inc. P. O. Box 218 North Wales, Penna.	445	150-1			✓			✓	✓				✓													
Thompson Ramo Wooldridge Inc. Canoga Park, Calif.	549-50 648	15			✓		✓	✓	✓						✓	✓	1		✓								2
The Timken Roller Bearing Co. Steel & Tube Div. 1835 Dueber Ave., S. W. Canton 6, Ohio	226							✓			✓				✓												
Tracerlab, Inc. Reactor Monitoring Center 2030 Wright Ave. Richmond, Calif.	620		✓	✓												✓	3				✓	✓				
Union Carbide Corp. See Linde Co. National Carbon Co. Oak Ridge National Laboratory Union Carbide Metals Co.	421-31																									
Union Carbide Metals Co. Div. Union Carbide Corp. 30 East 42nd St. New York 17, N. Y.	421-31																									5
United Nations 1st Ave. and 42nd St. New York, N. Y.	627	102																✓								
U. S. Nuclear Corp. P. O. Box 208 Burbank, Calif.	629			✓										✓		✓	4				✓	✓	✓			
United States Steel Corp. 525 William Penn Place Pittsburgh 30, Penna.	400-06							✓			✓				✓	✓										
D. Van Nostrand Co., Inc. 120 Alexander St. Princeton, N. J.	235																	✓								
Vard Inc. 2981 E. Colorado St. Pasadena 8, Calif.	220						✓		✓																	
The Victoreen Instrument Co. 5806 Hough Ave. Cleveland, Ohio	321	94-5	✓	✓	✓											✓					✓					
Vitro Corporation of America 261 Madison Ave. New York 16, N. Y.	316	111														✓	6			✓						
Wah Chang Corp. 233 Broadway New York 7, N. Y.	200	37																								7
Westinghouse Electric Corp. Atomic Power Department P. O. Box 355 Pittsburgh 30, Penna.	420-24	93 159	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓										

1 Electromechanical systems engineering 2 Closed-circuit TV 3 Activation analysis
4 Waste-disposal service & systems 5 Pure metals; chemicals, metal 6 Architect-engineering
7 Metals

1960 NUCLEAR CONGRESS

6th NUCLEAR ENGINEERING & SCIENCE CONFERENCE

MONDAY - April 4th

9:30 a.m. — ALL-CONGRESS SESSION
Demands from Engineers of Future Development of Nuclear Energy.

2:00 p.m. — MATERIALS AND COMPONENTS I
Metal, Ceramic, Organic Materials

ENVIRONMENT I
Plant Construction and Site Location

REACTORS I
U. S. Power Reactors

TUESDAY - April 5th

9:30 a.m. — MATERIALS AND COMPONENTS II
Fuel Technology

ENVIRONMENT II
State-Federal Regulations Protecting Public Health

REACTORS II
Research Reactors and Radiation Facilities

2:00 p.m. — ENVIRONMENT III
Water Supply and Waste Disposal

REACTORS III
Progress in Reactor Instrumentation

NUCLEAR STANDARDS SESSION
Discussion of nuclear standards development by four speakers representing four specification and code-writing organizations interested in nuclear standards.

WEDNESDAY - April 6th

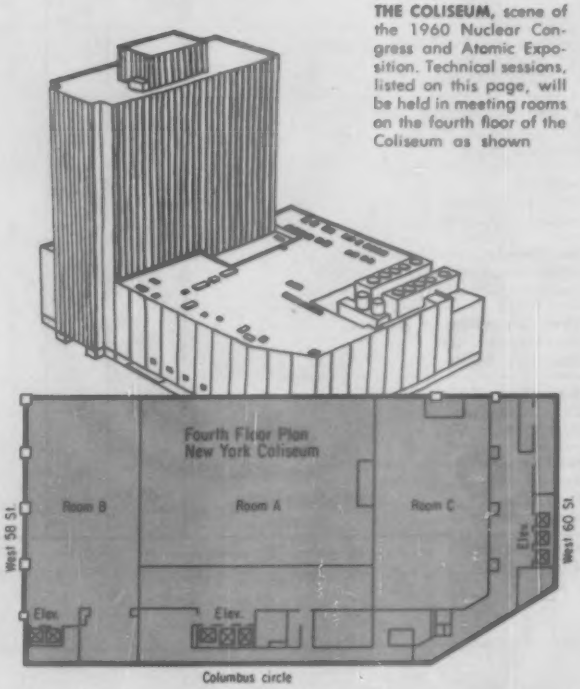
9:30 a.m. — REACTORS IV
Advanced Reactors and Fuel Cycles

ISOTOPE APPLICATION SESSION

2:00 p.m. — RADIATION PROCESSING SESSION

REACTOR DESIGN ENGINEERING SESSION

6:00 p.m. — ALL-CONGRESS BANQUET
Grand Ball Room, Statler Hilton Hotel



THE COLISEUM, scene of the 1960 Nuclear Congress and Atomic Exposition. Technical sessions, listed on this page, will be held in meeting rooms on the fourth floor of the Coliseum as shown

NUCLEONICS

JEROME D. LUNTZ, *Editor and Publisher*

MARCH, 1960

The National Laboratories

THE ATOMIC bomb project was successful in World War II because of the capability of the United States to marshal a diversity of talents in a very short time. Industry, universities and the government pooled their efforts in a magnificent manner, with much of the work centered at large research and development installations. Although such large-scale attacks on difficult problems were not a new idea, the war conclusively taught us that much could be gained for the welfare of the U. S. by building up strong centers of nuclear research and development. Also, the cost of such research was expected to continue to be high, much too high for nongovernmental organizations.

This was the genesis of the mammoth present-day laboratories of the Atomic Energy Commission. To turn atomic swords into ploughshares, money and talent on a large scale would be necessary.

THE NATIONAL laboratories have been eminently successful. They are looked to throughout the world as the source of nuclear strength for the U. S. And, in fact, they are. Not only have the labs made major contributions to virtually all phases of nuclear science and technology, but they have also bolstered our knowledge in many other areas: e.g., the life sciences, metallurgy and solid-state physics.

The labs have been successful in large part because they have been able to attract the very best talent. Competence attracts competence. More importantly, perhaps, competence breeds new competence. Thus, the national labs have been the spawning ground for nuclear talent that has spread throughout the U. S. and even throughout the world.

With a report on the role of the labs due to go to the Congress from AEC, and with Congressional hearings expected to be held on the subject, the labs are presently a subject of controversy (see NU, Jan. '60, 22). There are those who apparently would like to see the labs have a considerably reduced role. There are those who feel that there are certain kinds of activities that the labs should not engage in.

Most people, however, are in agreement on the importance of the labs and on the need for their continuance. The AEC and the labs themselves seem generally to be in agreement on the basic purpose of the labs—to keep the U. S. in the forefront of nuclear technology by working on new ideas, basic ideas, ideas that are nowhere close to fruition in a commercial sense.

We believe that the labs are a vital force in our nuclear program and must continue to be. We believe too, that, on occasion, they have strayed from their primary function and have gotten into commercial type articles, manufacturing, for example.

IT SEEMS to us that the most important element in having the labs perform their most useful function—as stimulator of nuclear technology—is the attitude of the directors of the laboratories and their key personnel towards the relative roles of the labs and outside groups (industry, universities, research organizations). If it is recognized that the laboratories have two primary purposes—to work at the forefront of the field and to foster the development of a strong nuclear industry by working closely with it—then the best interests of the U. S. will be served.

In this way, the strength of the national laboratories will be maintained and the growth of the outside industry will be encouraged.

Uranium Monocarbide—

UC is a strong contender as a reactor fuel because of (1) higher burnup and operating temperature than metallic fuel, (2) higher thermal conductivity and uranium density than UO_2. Problems are reactivity with water, pyrophoricity and thermal-stress cracking

By F. A. ROUGH and R. F. DICKERSON, *Battelle Memorial Institute, Columbus, Ohio*

IF AN IDEAL REACTOR FUEL is defined as a material with the thermal conductivity of a metal, the high melting point of a ceramic and the irradiation stability of UO_2 as well as high uranium density and amenability to relatively low-cost production, uranium monocarbide is a leading candidate.

Materials-compatibility studies show the monocarbide to be particularly suitable for sodium-, organic- and high-temperature-gas-cooled reactors. However, the reaction of UC with water can be violent. This will probably rule out water-cooled reactors unless sufficient safeguards can be provided by design or cladding.

Although uranium monocarbide preparation has been studied sporadically for at least 10 years, only recently has there been a systematic effort to assay its fuel potentialities. This current interest stems less from new data on UC than from greater familiarity with metallic fuels and UO_2—certain of their shortcomings are unlikely to be altered substantially by further development.

A number of groups are now involved in UC studies: Atomics International, Battelle Memorial Institute, General Atomic, Nuclear Development Corporation of America, Nuclear Materials and Equipment Corp., Olin Mathieson Chemical Corp. and Union Carbide Metals. For the most part, these projects are in the initial stages. In particular, very little irradiation data is available. However, enough information is available to warrant the present interim report.

Properties of UC

In Table 1, selected properties of UC are compared with those of UO_2 and metallic uranium. The carbide approaches or equals some of the favorable properties of the other two while avoiding the most unfavorable.

Effect of composition. Figure 1 shows the microstructure of stoichiometric UC (4.8 wt % C) as well as compositions containing more (5.0 wt %) and less (4.4 wt %) carbon. In the case of the 4.4 wt % C, the white material in the grain boundaries is free uranium. Although no data are available, this free uranium might be undesirable from the viewpoint of radiation damage—radiation-induced growth of the uranium areas could lead to internal stresses and excessive cracking.

In the case of material containing 5.0 wt % C, the excess carbon is accommodated as UC_2. The UC_2 is identified as the white platelets appearing within the grains. Again, one could postulate that UC_2 might be detrimental to radiation resistance. However, irradiation data reported in subsequent paragraphs show favorable results from similar material containing about 5.2 wt % carbon. Clearly, additional data are needed to establish the optimum composition for radiation hardiness.

Miscibility with other carbides. A number of investigators (*12*) have demonstrated complete miscibility of UC with UN, ZrC and TaC. There is only partial solubility between UC and TiC, UC and NbC, and UC and VC. There is negligible solubility of carbon or uranium in UC at temperatures below 1,650° C, whereas UC and UC_2 exhibit mutual solubility at temperatures above 1,980° C.

Compatibility with other materials. The results of corrosion tests in water, as well as tests of UC compatibility with other media and materials, are summarized in Table 2 (*4, 10, 13–16*).

Uranium monocarbide has very poor compatibility with water at any temperature. Experience indicates that the material is unstable in moist atmospheres and must be stored in dry air or an inert atmosphere to prevent slow disintegration at ambient temperatures.

Unfavorable properties of UC. Several properties of UC, in addition to its instability in water, may limit its use or require consideration in handling and fabrication.

UC powders are pyrophoric, discouraging the use of powder-metallurgy techniques because of the need for inert-atmosphere handling. However, small pieces of the material can be handled in air with minimum care.

As would be expected, UC is quite

Fuel of the Future?

TABLE 1—Comparison of Properties of UC, UO_2 and Uranium Metal

	Uranium monocarbide	*Uranium dioxide**	*Uranium metal†*
U density (gm/cm^3)	12.97	10.5	
Melting point (°C)	2,315 ± 65	2,750 ± 40	1,133 ± 1
	UC melting points of 2,250°–2,375° C are reported		
Thermal conductivity (cal/sec/cm/°C)	0.06 at 100°–700° C for 5 wt % C (*5*)	0.018 at 100° C‡ 0.012 at 400° C‡ 0.008 at 700° C‡	0.065 at 100° C 0.081 at 400° C 0.104 at 700° C
	UC thermal conductivity believed to be about the same for 4.8 wt % C and higher for <4.8 wt % C at elevated temperatures		
Crystal structure	Face-centered cubic to melting point (*1, 2*)	Cubic fluorite type	Orthorhombic, tetragonal and body-centered cubic
	Largest spherical lattice vacancies in UC crystal structure are 0.50 A in radius and occur at tetrahedral positions of unit cell		
Theoretical X-ray density (gm/cm^3)	13.63	10.97	Orthorhombic: 19.12; tetragonal: 18.11; cubic: 18.06
Bond	Covalent and metallic	Covalent and ionic	Metallic
	U-C bonding probably consists of 4 covalent and 2 metallic bonds per uranium atom (*3*), accounting for partly metallic, partly nonmetallic behavior		
Electrical resistivity (microhm-cm)	4.8 wt %/°C—41.2 (*4*) 5.0 wt %/°C—41.9–43.2 (*4*) 6.75 wt %/°C—50.8 (*4*)	10^2 to 10^6 (surface effects important; goes down as temperature goes up: behaves as semiconductor)	29
	Measurements made on cast UC; little difference over range 2.4–6.75 wt % C		
Linear coefficient of expansion (10^{-6}/° F)	68–200° F–5.5 68–1,600° F—6.4	81–752° F–5.1 752–1,472° F—6.0 1,472–2,300° F—7.0	77–1,157° F *a* direction—19.5 *b* direction——4.72 *c* direction—18.1 vol. coeff.—32.9 × 10^{-6} in^3/in^3/°F
	Measurements made on cast UC (*5*); coefficient less for UC made from powder		
Room-temperature hardness	Cast: 560 VHN (*6, 7*) Sintered (2.100° C): 750–780 VHN (*8*)		290 VHN (after 50% reduction)
	Difficult to evaluate data reported for pressed and sintered UC because of variations in conditions of preparation and fabrication		
Elastic modulus (10^6 psi)	Cast: 32 (determined in compression)	25–30	25.5 (average)
Crushing strength (psi)	Cast: 54,500 (*9*)	150,000	
	In single determination reported, UC fractured at 54,500 psi after completely elastic strain of 0.17%		

* Unless otherwise noted, the UO_2 data were obtained from reference *10*.
† Unless otherwise noted, the uranium data are from reference *11*.
‡ Values obtained by extrapolating to 100% density. Measurements made on 10.2-gm/cm^3 UO_2 (H. Deem, J. Matolich, BMI).

brittle. It would probably fracture under high thermal stress.

Finally, evolution of hydrocarbons and hydrogen may present a problem in chemical processing of spent fuel.

Preparation

Uranium monocarbide has been prepared by gas-solid reaction, solid-solid reaction and liquid-solid reactions. Litz (*1*) heated powdered uranium in a stream of methane at about 650° C to form uranium hydride, which reacted at increased temperature with the methane to form the monocarbide. The material has also been prepared by direct combination of uranium powders with graphite or by reducing UO_2 powder with graphite (*8*). Our laboratory (*17*), Oak Ridge (*18*) and others have successfully used the reaction of molten uranium and graphite.

Shapes have been fabricated by several techniques. Compacting and sintering UC powder produced densities of 12 gm/cm^3 or an effective uranium density of 11.4 gm/cm^3, which exceeds the uranium content of 100% dense UO_2 (*8*). Tubular carbide shapes have also been produced by preforming UC with temporary wax binders. Shapes having densities of more than 98% can also be consistently produced by melting uranium in the presence of graphite in an inert-electrode, inert-atmosphere arc furnace and casting the molten compound. Hot pressing followed by sintering of uranium and carbon powders as a means of fabrication is also being studied.

Casting appears to be the best process for obtaining reproducibly high-density, good-quality material. Sound shapes ⅜ in. in diameter and 2 in. long, requiring only slight machining, are being produced consistently (*17*). Compositions accurate to ±0.1 wt % C can be attained with confidence (*19*). The process used in this case consists of prealloying uranium and graphite into a button by inert-electrode arc-melting, remelting the button and gravity-casting the molten material into a graphite-thimble mold.

The process has been scaled up by

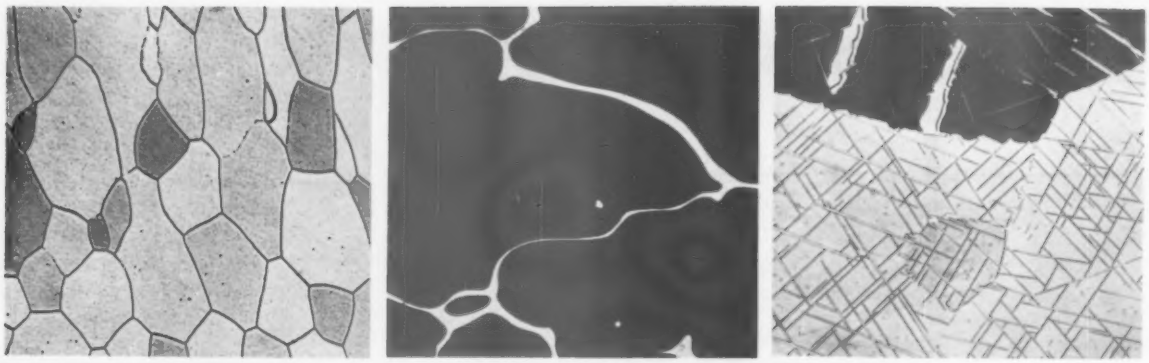


FIG. 1. EFFECT OF CARBON CONTENT ON UC MICROSTRUCTURE. At left, stoichiometric UC (4.8 wt % C); single-phase structure. Center, 4.4 wt % C; white constituent in grain boundaries is U metal. At right, 5.0 wt % C; needle-like structure is UC_2. Nonstoichiometric compositions might have less radiation resistance because of uranium growth and UC_2 damage

using a skull-melting technique. A molten bath of UC, built up in a skull of UC serving as the arc-melt crucible, is poured into suitable molds. Cylindrical castings as large as 1 in. in diameter and 8 in. long, as well as other shapes, have been produced by this technique (see Fig. 2). Although complete analytical data are not yet available, we believe that compositional control will be as good as that achieved in the small castings.

For the most economical process, the carbide should be produced without going through the metal stage. The carbide could then be melted and cast into the desired shape. With the development of a suitable process for producing UC directly from the green salt and refinement of the casting process, UC fuel-element shapes should cost less to produce than UO_2 shapes.

Effects of Irradiation

To help fill what is perhaps the most serious gap in UC technology—the lack of data on irradiation stability—Atomics International is directing an irradiation testing program with assistance from Battelle. The program consists of seven capsules containing cast, unclad UC in NaK which will be irradiated to burnups of up to 2% U (15,000 Mwd/ton UC). Evaluations have been completed for three capsules irradiated to burnups of 0.85 atom % (Table 3), and preliminary examinations have been made of specimens irradiated to 1.93 atom %.

In capsules *B* and *C* (Table 3), cracks were both radial and transverse; the concentration of cracks was slightly higher in the specimens having the higher thermal stresses. The specimens in capsule *A*, which were irradiated at low temperatures and low thermal stresses, were not cracked.

Density decreases were not proportional to burnup. For example, capsules *B* and *C*, which differed in burnup by a factor of four, showed nearly the same density decreases. It is believed that internal cracks and surface damage caused by absorption of oxygen from the NaK in the capsules obscured the true density changes caused by irradiation. The cracked and somewhat roughened postirradiation surfaces would be eliminated if higher purity NaK were used, or if the specimens were sealed in cladding having a small NaK or sodium annulus. Figure 3 shows postirradiation appearance.

Fission-gas determinations were made on capsules *B* and *C* using Kr^{85} as an index. In capsule *B*, the fission gas collected agreed closely with the calculated release by recoil from the surfaces. In capsule *C*, the actual release was about three times the calculated amount, but this was only about 0.1% of the total Kr^{85} generated.

Initial postirradiation examinations have recently been performed on

TABLE 2—Compatibility of UC with Various Materials

Medium or material	*Temperature (° C)*	*Remarks*	*Refs.*
H_2	High	Compatible if no second phase present	*10*
NaK	1,000	Compatible under static conditions after 1-month exposure	*13, 14*
Ethyl and butyl alcohols, benzine, xylene	20	Compatible	*13, 14*
H_2O	60	2-hr exposures: 638 mg/cm²/hr for 4.8 wt % C; 1,050 mg/cm²/hr for 5.0 wt % C	*4*
H_2O	80	Rapid decomposition	*10*
CO_2	500	Oxidizes in 8-atm. gas pressure	*10*
Terphenyl (Santowax R)	350	6 mg/cm²/hr for 5.0 wt % C; 0.3 mg/cm²/hr for 6–8 wt % C	*15*
Ethylene glycol	150	0.4 mg/cm²/hr	*15*
Magnesium	600	No reaction in 24 hr	*15*
Niobium	500	Probably compatible	*10*
Tantalum	1,000	No reaction in 24 hr	*15*
Inconel	1,000	Marked reaction in 24 hr	*15*
Mild steel	1,000	Marked reaction in 24 hr	*15*
304 stainless steel	1,000	Marked reaction in 24 hr	*15*
Zirconium	1,000	Marked reaction in 24 hr	*15*
Aluminum	600	Slight reaction in 24 hr	*15*
Titanium	1,100	Reaction in 24 hr	*10*
	1,200	Marked reaction in 24 hr	

TABLE 3—Results of Irradiating Cast, Unclad Uranium Monocarbide Specimens

Irradiation capsule	Preirradiation specimen data			Irradiation temperatures (°F)				Postirradiation data		
				Surface		Center				
	Composition (wt % carbon)	Diameter (in.)	Length (in.)	Max.	Mean	Max.	Mean	Burnup (atom % U)*	Density decrease (%)†	Remarks
A	5.2	¼	½	600		660		0.09	0.4–0.5	No cracks
B	5.2	⅜	2	900	770	1,600	1,330	0.16–0.21	0.7–2.5	Some stress cracks
C	5.1–5.2	⅜	2	1,075	915	1,830	1,375	0.63–0.85	0.6–2.5	Slightly more stress cracks

* Based on dosimetry. † Range represents number of specimens or pieces of specimens.

specimens irradiated to a maximum calculated burnup of 1.39 atom % U as a mean surface temperature of 765° F (*20*). These specimens were cast, measured ⅜-in. diameter by 2 in., and contained 5 wt % C. The effects appeared to be no more severe than those resulting from the lesser burnups discussed in the preceding paragraphs.

Irradiation results obtained to date indicate that UC behaves in a manner similar to UO_2. On the other hand, unalloyed or low-alloyed uranium would be damaged seriously by swelling at these temperatures and burnups. Even though when completed the Atomics International-Battelle program will provide data on higher burnups, much more effort will be needed to provide a complete picture of irradiation behavior.

BIBLIOGRAPHY

1. L. M. Litz, A. B. Garrett, F. C. Croxton. Preparation and structure of the carbide of uranium, *J. Am. Chem. Soc.* **70**, 1718 (1948)
2. R. E. Rundle, N. C. Baenziger, A. S. Wilson, R. A. McDonald. The structures of carbides, nitrides, and oxides of uranium, *J. Am. Chem. Soc.* **70**, 99 (1948)
3. A. E. Austin, unpublished discussions
4. W. M. Phillips, E. L. Foster, R. F. Dickerson. Progress relating to civilian applications during June, 1959, BMI-1357, confidential
5. H. W. Deem, unpublished discussions
6. F. A. Rough, C. A. Smith. The physical properties of uranium monocarbide, *Nuclear Sci. & Eng.* **6**, 391 (1959)
7. A. C. Secrest, E. L. Foster, R. F. Dickerson. Progress report for January, 1958, BMI-1253, p. 61 (1958)
8. E. Barnes, W. Munro, R. W. Thackray, J. Williams, P. Murray. The preparation, fabrication, and properties of uranium carbide, in "Progress in Nuclear Energy V, Metallurgy and Fuels," p. 435 (McGraw-Hill Book Co., New York, 1956)
9. J. Melehan, F. A. Rough. Progress report for October, 1958, BMI-1301, p. 47 (1958)
10. R. W. Nichols. Ceramic fuels—properties and technology, *Nuclear Engineering* **3**, 327 (1958)
11. D. H. Gurinsky, G. J. Dienes, "Nuclear Fuels" (D. Van Nostrand Co., Princeton, 1956)
12. H. Nowotny, R. Keiffer, F. Benesovsky, E. Lamb. Contribution to the knowledge of the partial systems UC with TiC, ZrC, VC, NC, Cr_3C_2, Mo_2C, and WC, *Monatshefte für Chemie* **88**, 336 (1957)
13. R. B. Price, R. H. Barnes, K. A. Chandler, G. D. Calkins. Progress report for March, 1958, BMI-1256, p. 58 (1958)
14. R. B. Price, R. H. Barnes, K. A. Chandler, G. D. Calkins. Progress report for February, 1958, BMI-1256, p. 58 (1958)
15. W. M. Phillips, E. L. Foster, unpublished discussions
16. CT-423, "Corrosion of U_3C_5 and UC_2 by Bismuth," Technological Research Section II Report for January 15, 1943
17. A. C. Secrest, E. L. Foster, R. F. Dickerson. Preparation and properties of uranium monocarbide castings, BMI-1309 (1959)
18. R. J. Gray, W. C. Thurber, C. K. H. DuBose. Preparation and metallography of arc-melted uranium carbides, ORNL-2446 (1958)
19. E. L. Foster, BMI, unpublished data
20. S. Alfant, A. W. Hare, unpublished discussions

FIG. 2. UC CASTINGS prepared by arc-melting in UC skull and tilt-pouring into mold These castings have not been cropped or machined

FIG. 3. FUEL DAMAGE, such as thermal-stress cracking (end view) and surface roughness probably caused by oxygen in NaK (longitudinal view), can obscure radiation damage; specimen from capsule C, 0.85 atom % U burnup

Flux Perturbation by Detector Foils

A definitive set of measurements finds that analytical methods of predicting flux perturbations by foils in a thermal spectrum are valid over a wide range of foil dimensions

By ALAIN SOLA,* *Argonne National Laboratory, Lemont, Illinois*

Foil activation is one of the techniques commonly used to measure neutron flux, and the problem of flux perturbation by these detectors has been considered by many authors. A somewhat confusing impression arises from the different conclusions drawn by authors when they compare similar experiments with the existing theories. This is generally due to a lack of agreement on the definition of flux perturbation. Also, the different theories do not give the same results, presumably owing to differences in methods of approach. For these reasons a need has been felt to review the published experimental results and to conduct an experiment allowing comparison with the theories.

The necessary correction that must be made to the counting rate of a foil after irradiation to obtain a number proportional to the unperturbed flux is actually the result of two superimposed effects:

1. Absorption of neutrons by the foil. The flux in the neighborhood of the foil is lowered owing to that fraction of the available neutrons which is lost by absorption in the foil.
2. Self-shielding of the internal layers of the foil by the outer layers.

The first of these effects will be referred to as "flux depression H," the second as "self-shielding G" and the total effect as "flux perturbation."

A correction may also be necessary when a foil is irradiated in the presence of neighboring foils and when a foil is covered by a foil of different material. These corrections have been considered elsewhere (*1–5*) and will not be discussed here.

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Flux Measurements

The results of flux measurements depend on several factors, such as the energy and angular distribution of the flux (*6*), the properties of the surrounding medium and the density, material and size of the detector.

Measurements made in a medium where the neutrons have widely distributed energies will depend on the neutron density and on the absorption cross section of the detector. The problem is difficult to treat theoretically, even for the case of isotropic flux (*7*). In the range where the cross sections follow a $1/v$ law, the detector activation will be proportional to neutron density, independent of the shape of the neutron spectrum. In the resonance regions, where the cross section varies rapidly with energy, one can use resonance detectors, which are sensitive only to neutrons within a certain narrow energy range. After one crossing of the detector, a neutron of this energy would have to be scattered in the medium before returning to the detector. Since its energy will then be lower than the resonance energy, the perturbation of the flux by the detector is negligible.

The dependence on angular distribution has been discussed by Bothe. The error made by assuming an isotropic distribution will be small, even for relatively thick detectors.

Perturbation by Detectors

Bothe gives formulas for correcting the effects due to self-shielding and flux depression. The self-shielding factor for an isotropic flux is (*6, 7*)

$$G = \frac{1 - e^{-x}(1 - x) - x^2 E_1(x)}{2x} \quad (1)$$

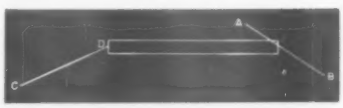


FIG. 1. EDGE ABSORPTION in finite foil affects counting rate in flux-detection experiments. This tends to increase value of self-shielding factor G

where x is the foil thickness measured in mean-free-path units and

$$E_1(x) = \int_x^\infty \frac{e^{-s}}{s}\, ds$$

The factor G is obtained by considering the foil as part of an infinitely thick plane in an unperturbed isotropic flux. A foil used in an experiment, however, is of finite size, and the contribution to the counting rate due to neutrons following paths such as AB or CD (Fig. 1) is overestimated. Except for very small foil radius, this effect will be very small in media with a large mean free path, such as gold ($\lambda \simeq 0.17$ cm) or indium ($\lambda \simeq 0.14$ cm), and small even in a medium such as dysprosium ($\lambda \simeq 0.036$ cm). Skyrme (*8*) has considered the case of a disk in an isotropic flux. For thicknesses less than $\frac{1}{10}$ mean free path, he finds a corrective factor for self-shielding which is smaller than G by about 0.5%.

The error made by assuming that the neutron density is constant around the foil is more important. Since the neutron density decreases with decreasing distance from the foil, the value given by G will be too low. Examining the depression of the flux in the surrounding medium by the foil, Bothe envisaged the case of a spherical detector and arrived at a formula for a disk by intuitive means. This was slightly

modified by Tittle (*4*), who gives for the factor H by which the absorption of the detector diminishes the number of incident neutrons

$$H = \frac{1}{1 + \frac{\alpha}{2}\left(\frac{3}{2}\frac{R}{\lambda_{tr}}\frac{L}{R+L} - 1\right)} \quad \text{if } R > 2\lambda_{tr} \qquad (2a)$$

or

$$H = \frac{1}{1 + 0.34\alpha\frac{R}{\lambda_{tr}}} \quad \text{if } R \ll \lambda_{tr} \qquad (2b)$$

where R = foil radius, cm

λ_{tr} = transport mean free path in medium around foil, cm

$$\alpha = 1 - e^{-x}(1 - x) - x^2E_1(x)$$

$$L^2 = \frac{\lambda_{tr}\lambda_a}{3\left(1 - 2\frac{\lambda_{tr}}{\lambda_a}\right)^2}$$

λ_a = absorption mean free path in medium around foil, cm

For a thermal flux, λ_a is calculated with a Maxwell averaged microscopic cross section. Figure 2 gives a plot of G and α.

The perturbation factor, that is, the ratio of the average flux measured by the detector to the unperturbed flux, is

$$F = GH \qquad (3)$$

The value given by F will be too low for thick foils. This is due to the error in the calculation of G. For thin foils the discrepancy will be small and its sign may depend on how accurately the theory describes the phenomenon.

Skyrme (*8*) has obtained correction factors for a circular disk. His results are presented in the Appendix.

Corinaldesi (*9*) has examined the theory of flux depression of a circular detector. The curves published are valid for a diffusion length of about 2 cm and hence could not be checked against measurements in graphite. Comparing these with their measurements in water, DeTroyer and Tavernier (*12*) found that the correction was intermediate between the values given by Bothe and Skyrme, and therefore the accuracy of this theory might be worth investigation in spite of its approximations.

From an experimental standpoint, several authors (*2, 6, 10–13*) have considered the problem of flux perturbation.

Bothe (*6*) in 1943 used Dy_2O_3 detectors in aluminum and in paraffin. The choice of these two media is interesting, since in aluminum $\lambda_{tr} \simeq 12$ cm and therefore $H \simeq 1$, but this is not the case in paraffin, where $\lambda_{tr} \simeq 0.4$ cm. In 1951, Tittle (*4*), using more recent values for the diffusion constants, found that Bothe's experimental data fitted well the flux-depression formula after some modifications (see Eqs. 2). Klema and Ritchie (*10*) used ¾-in.-radius gold and indium foils in graphite with thicknesses of 1–5 mils. They find good agreement with either Bothe's or Skyrme's theory. Their results have been normalized arbitrarily since the point at zero thickness is not available.

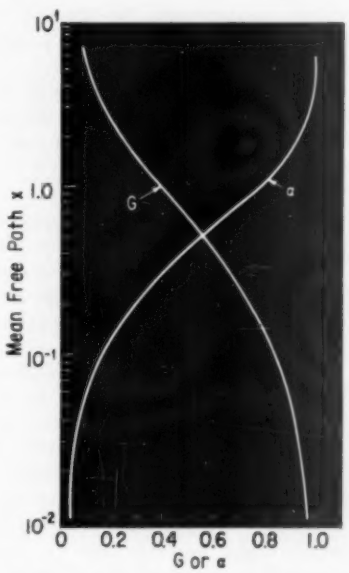


FIG. 2. PLOT of self-shielding effect G and parameter α as function of mean free path

Gallagher (*11*) used ⅜- and ¾-in.-radius gold foils in graphite with thicknesses of 0.5–5 mils. His data are normalized arbitrarily. For ⅜-in.-radius foil the agreement with Bothe's theory is good, but for ¾-in.-radius foil the data do not follow either theory but "seem to fit Skyrme's slope in the range 0.5 to 1.5 mils and Bothe's slope in the range 1.5 to 5.0 mils." This last conclusion is not, however, evident from a mere examination of the published curve.

Fitch and Drummond (*13*) used ¼-in.-radius indium foil in water with thicknesses of 1–9 mils. The agreement with Bothe's theory is good.

DeTroyer and Tavernier (*12*) made measurements with ½-in.-radius indium foils 1–9 mils thick. The extrapolation to zero thickness is "made by using the function describing the depression and analyzing the data by least-square analysis around that function." For a 1-mil-thick foil the flux perturbation is found to be 5.2%. They compare this value with a correction of 6.3% as given by Skyrme's theory and 2.4% as given by Bothe's theory. This 2.4%, however, is due only to the flux-depression effect H. Indeed, for this thickness $G = 0.970$, $H = 0.975$ and $F = 0.970 \times 0.975 = 0.946$, giving a flux perturbation of 5.4%, in good agreement with the measured value.

Thompson (*2*) used 1- × ¾-in. indium foils in graphite. Data were taken in three neutron spectra, and the effect of the cadmium ratio is shown to be considerable. The foil thicknesses used in a thermal flux ranged from 0.4 to 12 mils. In comparing with the theories, Thompson assumed that a 1- × ¾-in. foil (area 4.84 cm²) is equivalent to a 1-cm-radius disk (area 3.14 cm²). The data fit fairly well with Skyrme's formula. Comparison with Bothe's theory was made without including a self-shielding correction G; therefore, the agreement was found to be poor. When the self-shielding correction G is included, the experimental data fit the computed data within a few per cent.

EXPERIMENTS

The agreement with Bothe's theory seems rather good so far. It is not known, however, over what range of thicknesses and foil radii the flux perturbation can be estimated from the theoretical formulas. For this reason it was decided to measure the flux depression in a graphite medium with circular gold foil, considering the effect of both thickness and radius changes.

Graphite was chosen since it is commonly used in reactor work. Gold was chosen as the detector material for several reasons: It has only one isotope, with a prominent resonance at 4.87 ev, a value not too close to thermal energies; the thermal cross section is 98 barns and varies as $1/v$ around this energy; the half-life of Au^{198} is 2.7 days; the decay scheme of Au^{198} is very simple, with 98.7% of the beta decay accompanied by a 411.8-kev

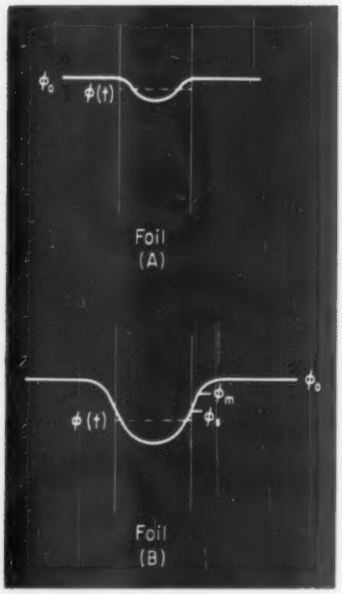


FIG. 3. FLUX-PERTURBATION FACTOR. (a) Partial flux-perturbation due to self-shielding only. (b) Total flux-perturbation due to self-shielding plus flux depression in surrounding medium from absorption of neutrons by the foil

gamma ray. Gamma counting is preferable to beta counting since the problems of self-absorption in the foils are minimized. As will be remarked below, gold does not allow the determination of G and H separately. This is not important, since it is the flux perturbation F that has a precise physical meaning and is the property that should be measured.

It would be interesting to measure G and H separately to check each formula individually. G is defined simply as the ratio of the value of the flux as measured with a foil detector, $\phi(t)$, to the value of the unperturbed, isotropic flux around the foil, ϕ_0 (see Fig. 3*a*). In fact, owing to the flux depression, G is preferably defined as $G = \phi(t)/\phi_m$, in which case $H = \phi_m/\phi_0$ (see Fig. 3*b*). ϕ_m is some average value intermediate between the unperturbed flux ϕ_0 and the flux at the foil surface ϕ_s. Since ϕ_m depends on the properties of the surrounding medium, G depends on these properties, although this is not seen in Eq. 1.

If the mean free path is small, α will be large and G small (large self-shielding effect) and the difference between ϕ_m and ϕ_s will be unimportant. In this case $G \simeq \phi(t)/\phi_s$ and $H \simeq \phi_s/\phi_0$. Then with a detector like dysprosium ($\lambda_a = 0.036$ cm), G and H can be measured separately. G can be obtained as the ratio of the average flux inside a foil to the flux at its surface. (This last value can be obtained, for instance, by irradiating a very thin foil in close contact with the detector.) H will then be obtained as $H = F/G$. It is also possible to use, as Bothe did, the same detector in two different media. In one of them (sodium, calcium, sulfur, aluminum or potassium) the transport mean free path is large and therefore $H \simeq 1$. The measurement will yield G. The second measurement in the other medium (Bothe used paraffin) will yield F and H.

When α is smaller (indium or gold), the differentiation between G and H will be more difficult. Indeed the only value that can be measured easily is the flux perturbation F. It appears that, for the two detector materials quoted above, the theoretical results fit the measured values well. This does not imply accuracy of the formulas for G and H but rather the accuracy of the formula for $F = GH$.

Let ϕ_0 be the unknown, unperturbed flux. The comparison of the fluxes $\phi(t_0)$ and $\phi(t)$ as measured with two foils of thickness t_0 and t will depend not only on the flux perturbation produced by the foils, but also on the self-absorption of the radiations through the foils and probably also on the change in geometrical setting in the counting equipment. As remarked by Thompson, it would be convenient to measure only identical foils, a foil of thickness $t = nt_0$ being replaced by n foils of thickness t_0. $\phi(t)$ will be obtained as the average flux through the stack.

Since zero-thickness foils cannot be used, it will be necessary to extrapolate to zero thickness the results obtained for small thicknesses. If $\phi(t_a)$, $\phi(t_b)$, $\phi(t_c)$, . . . , $\phi(t_0)$ are the values obtained with stacks of thicknesses $t_a > t_b > t_c > \cdots > t_0$, one may form the sequence

$$\frac{\phi(t_a)}{\phi(t_b)}, \frac{\phi(t_a)}{\phi(t_c)}, \frac{\phi(t_a)}{\phi(t_d)}, \ldots, \frac{\phi(t_a)}{\phi(t_0)}$$

A plot of these values as a function of thickness gives a curve that may be extrapolated to zero if t_0 is small enough, giving the perturbation factor $F(t_a) = \phi(t_a)/\phi_0$. Thereafter any perturbation factor $F(t_j)$ will be obtained as

$$F(t_j) = F(t_a)\frac{\phi(t_j)}{\phi(t_a)}$$

Experimental Arrangement

Circular foils with thicknesses ranging from 0.1 to 23 mils and radius ½, ¼, ⅛ and 1/16 in. were irradiated in the thermal column of the Argonaut reactor (*14*). The cadmium ratio is 180. Each foil was surrounded by at least 90 cm of graphite.*

The stack of foils was placed on a graphite disk. Two monitors were placed one on each side of the stack. The distance between each monitor and the stack was 20 cm. These monitors were used to measure variations in reactor power from one irradiation to the next.

Gamma counting was accomplished with a 2½- × 2-in. NaI(Tl) crystal coupled to a Du Mont 6363 photomultiplier followed by a single-channel differential pulse-height analyzer with window width 10% (100 kev) centered around the 411-kev photopeak of Au^{198}.

A 0.063-in.-thick aluminum disk was placed between the foils and the crystal to absorb the beta rays. It was ascertained that the crystal was very sensitive to changes in solid angle when foils of different thicknesses were placed upon it. For this reason 1-mil foils were used in the range 1 to 20 mils, and 0.1-mil foils in the range 0.1 to 1 mil. The results obtained with a 1-mil foil or with ten 0.1-mil foils were found to be identical after corrections.

The smallest foils were weighed with a microgram scale. Several corrections were applied to the counting rate:

- Background. The crystal was shielded with 4 in. of lead, reducing the background to a practically negligible fraction of the total counting rate from which it was subtracted.
- Gold decay. This correction is classical. The gold decay constant was taken as 1.7824×10^{-4} min^{-1}.
- Gamma backscattering in the foils. Various thicknesses of unirradiated gold were placed above an irradiated

* Recent measurements (*15*) seem to indicate that the diffusion length in this graphite is smaller than the 50 cm used in the calculations ($L \simeq 47$ cm). This is of small importance for the comparison with the theories.

sample. No change in counting rate was observed, as expected, since in the backscattering (Compton) process a gamma ray loses energy and no longer falls within the window of the single-channel analyzer.

• Gamma self-absorption. A very thin gold sample ($\simeq 4\ \mu g/cm^2$) was mounted on a Mylar film, itself supported by a graphite ring to keep the distance between the ring and the crystal constant at 120 mils. After irradiation, this sample was counted with various thicknesses of unirradiated gold (0–120 mils) between it and the crystal. The absorption was found to be exponential with an absorption coefficient of $\mu = 0.185$ cm^2/gm, close to the theoretical value (0.19 cm^2/gm) (*16*). The counting rate was then corrected by using a correction factor of $\mu t/(1 - e^{-\mu t})$, where t is the foil thickness. Small variations in foil thickness through a stack were taken into account by this correction.

• Dead time. The counting rate was generally high, and a correction for dead time was applied. The dead time was found not to be constant but rather to increase slightly with the counting rate.

Results

Figure 4 shows the results of the measurements. The flux-perturbation factor F is given as a function of foil thickness, with the foil radius as a parameter. The total standard deviations are less than 2%. In order to simplify the figure, only one experimental point is shown for a 0.1-mil thickness.

The comparison with Bothe's and Skyrme's theories is shown in Tables 1–4.

It can be seen that for up to 5-mil thickness both theories give almost identical values for F, Skyrme's data fitting the measured values slightly better. For larger thicknesses, Bothe's correction, although too large, fits the experimental data better. The agreement is still good up to a thickness of 15 mils (750 mg/cm^2). On the whole, Bothe's theory, as modified by Tittle, gives better accuracy over a larger range of thicknesses when an error of about 2% is permissible. The effect of radius change is evident. The agreement with Bothe's theory is better when the foil radius is small, as expected from the condition of validity of Eq. 2*b*. There is an optimum thickness for which the computed value of F is equal to the measured value. This thickness depends on the radius but is close to 7 mils, where the error is less than 0.5% in comparing with Bothe's formulas. For smaller thicknesses, the absolute error is smaller but cannot be computed with as good an accuracy.

From the results obtained by a rather large number of authors, it seems that Bothe's correction for the

(*Continued on page 141*)

Flux Perturbation for Circular Gold Foils in Graphite

	Perturbation factor for various foil thicknesses (in mils)							
	1	*2*	*3*	*4*	*5*	*10*	*15*	*20*
Foil radius 1/2 in.								
Measured	0.945	0.916	0.892	0.870	0.850	0.775	0.712	0.656
Bothe*	0.965	0.931	0.907	0.883	0.860	0.773	0.708	0.647
Skyrme	0.958	0.926	0.896	0.868	0.843	0.727	0.624	0.514
Foil radius 1/4 in.								
Measured	0.951	0.925	0.905	0.883	0.864	0.788	0.733	0.683
Bothe*	0.968	0.936	0.915	0.893	0.872	0.792	0.731	0.675
Skyrme	0.962	0.933	0.907	0.883	0.862	0.763	0.678	0.587
Foil radius 1/8 in.								
Measured	0.957	0.931	0.910	0.890	0.872	0.799	0.747	0.704
Bothe*	0.969	0.938	0.917	0.898	0.876	0.798	0.740	0.681
Skyrme	0.964	0.936	0.912	0.890	0.870	0.780	0.701	0.620
Foil radius 1/16 in.								
Measured	0.963	0.936	0.914	0.895	0.878	0.811	0.762	0.726
Bothe*	0.970	0.939	0.919	0.898	0.878	0.802	0.744	0.689
Skyrme	0.966	0.937	0.913	0.891	0.872	0.784	0.708	0.628

* Modified by Tittle.

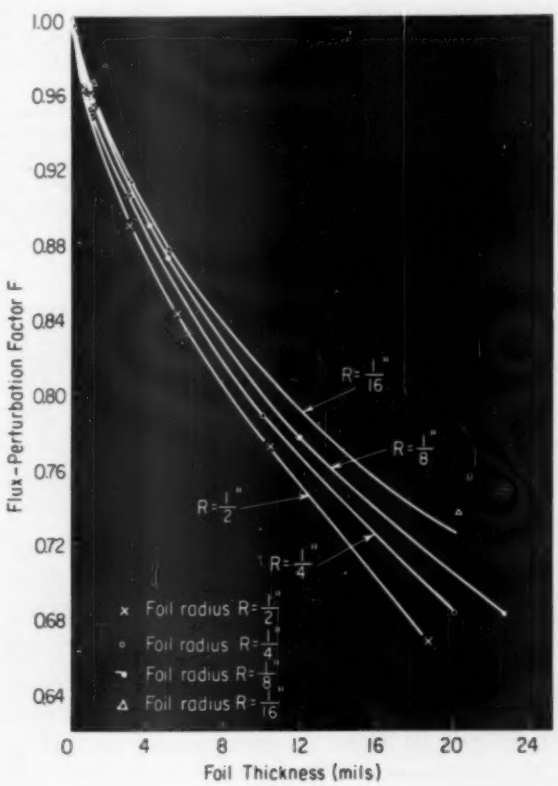
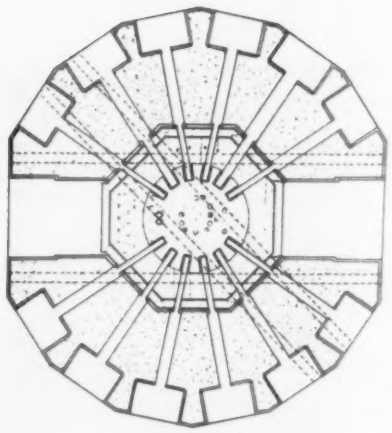


FIG. 4. FLUX-PERTURBATION factor F in graphite medium as function of gold-foil thickness, with foil radius as parameter. Experimental points were measured by author for foils exposed in thermal column of Argonaut reactor



EL-3 in plan view

Reactor Incidents

The two heavy-water research reactors at Saclay, EL-2 and EL-3, have successfully recovered from operating mishaps on several occasions. The history of those incidents can teach us all

P. BALLIGAND, *Centre D'Etudes Nucleaires de Saclay, Service des Grandes Piles Experimentales, France*

WHEN ONE ANALYZES the causes of reactor incidents, it is only in rare instances that one doesn't find that they could have been avoided, either by better supervision of procedures, or by precautionary measures that—after the incident—seem obvious. This is why it is always painful to one's pride to discuss this kind of setback.

The incidents to be described occurred during the period from Jan. 1, 1957, to July 1, 1959. They have not, however, hindered EL-2 and EL-3 from operating 80% of the time, including a month of shutdown scheduled annually for general maintenance.

DESCRIPTION OF EL-3

EL-3 is a 15-Mw heavy-water cooled and moderated research reactor with 10^{14} n/cm²/sec flux (see figures, above). Fuel is slightly enriched uranium 1.6%, alloyed with 2% molybdenum. There are 99 aluminum-clad fuel elements, disposed vertically in aluminum tubes. The heavy water flow is upward slightly pressurized (6 psi at the top of the tube) by means of a diaphragm. The normal operating temperatures of the water are 45° C at the bottom of a cell, and 60° C at the return to the tank. At the top of the tank, above the free surface of the heavy water, is a helium atmosphere with a pressure a few grams above the atmospheric pressure.

INCIDENTS AT EL-3

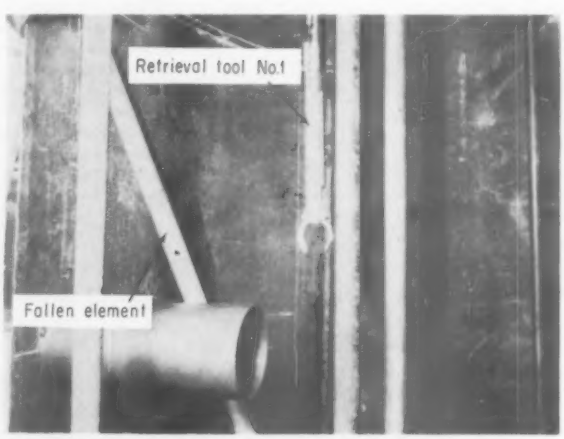
The only important incident encountered in operation of EL-3* took place at the conclusion of the full-power testing period. It was due to quite special causes. In contrast to EL-2, we have not yet been able to discover a cladding failure in EL-3, although some rods have reached 6,500 Mwd/ton exposure (Dec. '59).

The improved fuel life in EL-3 can be attributed to three factors; first, the fact that the fuel is alloyed with 2% molybdenum; second, the configuration of the elements, hollow cylinders cladded and cooled on the outside surface only; and third, the close bond between the fuel and cladding, obtained by machining thread-like grooves in the uranium and applying the cladding under heavy hydraulic pressure.

On Saturday night, April 13, 1958, EL-3 was taken to 15 Mw (flux of 10^{14} n/cm²/sec). The temperature of the uranium bars as read in a special thermocouple-equipped assembly was 400° C, and all operating conditions were normal. At 2 a.m. Sunday morning several alarm horns sounded at the same time, indicating excessive activity in various places. We at once verified

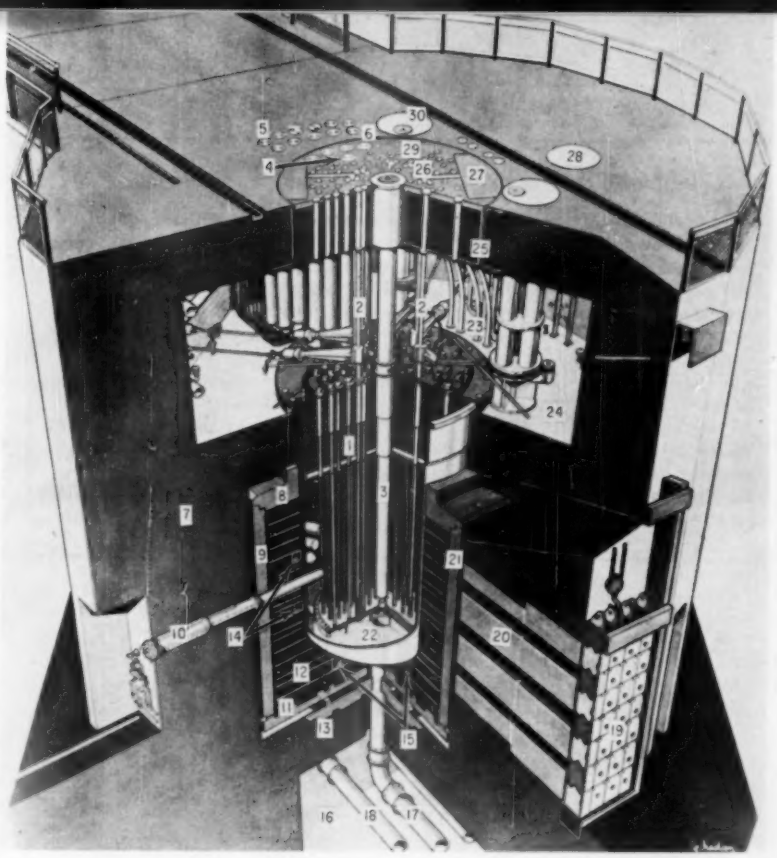
* There have been leaks of helium or of gas containing active particles coming from the channels. But in every case, the detection system for gases and active particles immediately gave the alarm, the personnel donned respirator masks to insure continued operation of the reactor, and the leaks were quickly traced and repaired.

FISHING FOR FUEL



1 FIRST RETRIEVAL TOOL is lowered to level of broken element resting against tank wall

at Saclay



EL-3, HEAVY-WATER RESEARCH REACTOR at Saclay that suffered from dislodged, melted fuel element. **1**-Safety, control, and shim rods, **2**-Control linkage of shim and control rods, **3**-Center tube, **4**-Converter tubes, **5**-Plugs of isotope tubes in graphite, **6**-Plugs of isotope tubes in tank, **7**-Concrete, **8**-Top shield, **9**-Cast-iron side shields, **10**-Radial tube, **11**-Bottom shield, **12**-Graphite reflector, **13**-Shield backing, **14**-Location of tangent tubes, **15**-Location of secant tubes, **16**-Lower chamber, **17**-Heavy water inlet, **18**-Heavy water outlet, **19**-Radiological protection, **20**-Graphite thermal column, **21**-Bismuth side shield, **22**-Tank, **23**-Pneumatically controlled tube circuit, **24**-Top chamber or "attic," **25**-False tabular block, **26**-Safety rod hood, **27**-Recess containing safety rod gear, **28**-Inspection hole, **29**-Cell plug

with a portable monitor that these signals really did correspond to abnormal activity in the reactor hall and were not due to a failure of line current to the built-in detectors. By the time we dropped the safety rods about 45 sec had elapsed.

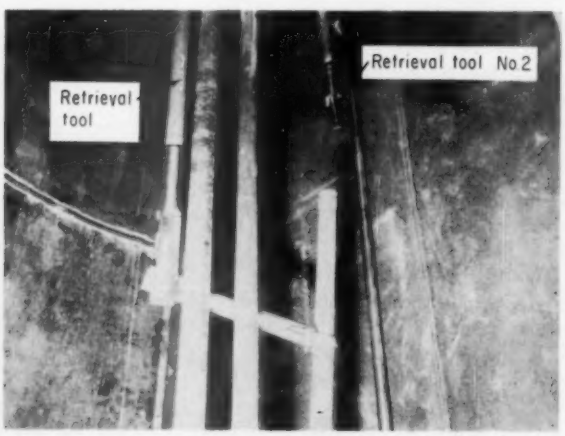
Shift personnel donned their masks; those who were not indispensable to the operation of the reactor were evacuated from the air-tight enclosure. A rapid reconnaissance of the entire building showed that the activity came from the helium recombiner and piping. We took some samples of gas before evacuating the containment vessel completely and moving the reactor operators on shift to the auxiliary console located in the machinery room outside the airtight vessel.

Analysis of the gas samples as well as a check of the personnel showed that there was no contamination in the reactor room. Moreover, the heavy-water activity monitors showed that there was a rather considerable contamination of the primary coolant circuit. Apparently we were dealing with a cladding rupture.

Measures Taken

Early Sunday morning a sampling of 500 cm^3 of helium was taken from the atmosphere in the reactor tank. Spectrometric analysis showed the presence of Xe^{133} and Xe^{135} and of slight traces

2 BROKEN ELEMENT IS GRASPED by retrieval tool and swung into position to be withdrawn



3 SECOND RETRIEVAL TOOL prepares to contact positioned element to complete mockup operations

Accident with In-Pile Experiment at EL-3

An incident at first quite inexplicable occurred with an experiment in the EL-3 reactor. Graphite blocks suspended by an aluminum apparatus were irradiated to a predetermined temperature (about 180° C) in the central channel of EL-3. During the night the safety rods fell as a result of reactivity increase. In checking the registered temperatures of the different experiments in the reactor, it was noticed that the graphite block in the central channel had probably fallen to the bottom, carrying away its thermocouples, after having been subjected to a very great rise in temperature. After 48 hours of searching for the cause of this accident, it was noticed that the filters installed on the central-channel CO_2 circuit had been blocked by paraffin from the shield of the plug of the central channel. It was decided to prohibit the use of paraffin in the shields when the temperature might rise and melt it. The experiment was dismantled and set up again in the reactor with a different plug.

of I^{133}. The Xe^{133} activity was evaluated at 100 curies for the entire 25-m^3 helium system. Calculations made on the basis of these data permitted us to estimate the weight of uranium oxidized at 1.6 kg. This estimate was subsequently verified by more direct measurement.

Samples of heavy water showed a large proportion of iodine fission products I^{131} and I^{133} and the characteristic lines of Xe^{131}, Xe^{133} and Xe^{135}. Microscopic examination of the filtration residues showed the presence of particles with a metallic look as well as grains of uranium oxide.

To find the damaged element, it was decided to take the reactor critical after replacing the atmosphere in the tank with clean nitrogen.

The active helium was evacuated through a system of filters especially installed for the purpose and through the facility's regular hot traps. The fixed monitoring stations around Saclay and a control jeep with radio liaison permitted keeping track at every moment of the activity of the air in the plume from the stack, which always remained below the normal activity with the reactor operating.

Unfortunately taking the reactor to 50 kw, didn't permit identification of the damaged element, the general activity of the system masked any particular signal.

We abandoned this procedure and began to pull the elements and radiograph them. At the eighth element, only the plug was brought out by the discharge machine, the rest of the fuel cell remained in the tank.

Observation by periscope through the water in the tank vessel gave no results, and so the unloading of the neighboring elements was continued. All this while the water was continuously purified by passage through ion exchangers. Afterward the heavy water was emptied through ion exchangers to storage tanks in the basement.

It then became possible to inspect the reactor tank properly. We noted that one fuel cell was broken at the level of its plug and had fallen across the bottom of the tank. The position of the cell was measured to within a few millimeters with the aid of reference points in the tank. The cell position thus determined carried over to a working drawing by descriptive geometry. Equipment for recovering the cell was drawn full scale on the working drawing: a moving arm was to descend through a neighboring aperture, grasp the cell, restore it to a vertical position, then a second arm with special tongs was to grasp the cell in its vertical position so that it could be disposed of with the usual discharge cask.

Considerable time was required for the fabrication of the equipment. During that time exact mock-ups of the tank and of the damaged element were built outside in the machinery room. Personnel responsible for the recovery of the rod were then able to practice the retrieval operation (see p. 82). On May 16, the fuel cell was removed in less than one hour on the first try. The heavy water was thereupon decontaminated and the reactor reloaded in 48 hours, ready to resume operation.

In going back to power, everything was normal except that the fission-product activity of the helium in the atmosphere of the calandria had increased by a factor of 30 in steady-state operation.

At the present time the activity in the helium 2 hr after shutdown is estimated at 0.2 curies/m^3, which according to calculations would correspond to a value of 1 gm of bare uranium in a free state in the tank. This uranium is probably stuck to the aluminum sides of the tank.

Post Mortem

Examination of the remains of the damaged element permitted determination of the causes of the accident. In EL-3, the fuel rods are mounted in aluminum tubes (called cells) which are fitted with conical bases that fit into holes in the bottom plate of the tank. The damaged rod was in every way identical with the other elements of the reactor, but it had been mounted in a tube whose base had been shortened by several millimeters so that it could be inserted in place of the tube of the central channel during certain low-power experiments. This fuel tube was later loaded by mistake into a normal position in the lattice. Given the very slight difference between this tube and a normal tube, the flow of water in the cell did not change notably and consequently its operating temperature was normal.

The cell therefore worked perfectly well during the two months of going to power and testing; but, being poorly supported at the bottom of the calandria, it vibrated under the effect of water flow until the welding of the cell to the plug broke. The cell then fell across the bottom of the tank. Its cooling being no longer assured by forced circulation of heavy water, the fuel rod melted in an extremely short time.

This unfortunate incident gave us specific information on the consequences of a sudden cladding failure in a heavy-water system. It showed us that only the radioactive rare gases pass into the calandria cover gas and that the other fission products—and in particular the iodines—remain in the water, from which they can easily be extracted with ion-exchange resins. This incident also led us to modify the burst-slug detection system by introducing a delay in the injection of helium into the recorders and by installing a scram signal on the reading of the helium activity in the recombiner circuit.

Incidents with EL-2 Reactors

EL-2 is a heavy-water-moderated reactor cooled by a closed-cycle CO_2 circuit. It is fueled with natural uranium contained in aluminum tubes. Cylinders of uranium, aluminum-clad and water-cooled, are used in horizontal channels as neutron converters. The most notable incidents have been due either to rupture of fuel-element cladding or to faulty cooling of the neutron converters.

Cladding rupture (Oct. 6, '57). Signs of abnormal activity in one fuel rod were noted by the burst-slug-detection system. After the progress of the cladding-failure had been followed for several days, the rod was removed. The CO_2 coolant, slightly contaminated, was expelled up the stack after being filtered to such a concentration that its activity remained below the permissible tolerance level of 4 mc/m³. From this date forward similar incidents were to recur. The solution would have been to replace the entire loading of fuel rods, but we laid great store on pushing irradiation time of the rods to the maximum, to derive indispensable data for the metallurgical development.

Converter meltdown (Nov. 26, '57). This incident is of the same type as the preceding incident involving a converter, but this time the incident occurred while the reactor was running. The safeguards functioned well and the reactor was scrammed. However, the delay between the cessation of flow and the effective shutdown of the reactor added to the decay heat in the uranium in the converters and caused it to melt.

Water infiltrating into the graphite of the reflector created such a negative reactivity (-0.4%) that the chain reaction stopped.

For a few seconds the graphite-cooling air transported fission-product gases—16 times the normal activity—up the reactor stack. All particles were retained in the fine filters installed before the stack. The water that leaked into the lower chamber of the reactor registered activity there of 2 r/8 hr; it was pumped out and evacuated to the hot waste-disposal tank.

Up to this point the consequences were minimal. Unfortunately when the damaged converter was unloaded, insufficient precautions resulted in a slight but general contamination of the reactor room that was to require three weeks of tedious cleaning. The reactor was started up well before completion of this cleanup, but the decontamination work forced all but a few experimenters to stay out of the reactor room.

As a result of this incident the security of the converters' cooling systems was improved and protective coatings of strippable paint and polyvinyl panels are now to be used when badly contaminated material is to be removed.

"Conventional" cladding rupture (Dec. 27, '58). Activity monitors gave ample warning of cladding failure but the shift supervisor, become too daring because of the slow development of the previous cladding failures, waited a little too long before stopping the reactor. The contamination of the CO_2 system was more severe than customary—20 times the usual level. Certain points in the system were contaminated, for example the blower rotors exhibited 4 times maximum permissible level. Nevertheless the damaged rod was withdrawn in the normal times, 48 hr, and the CO_2 was replaced by fresh CO_2. To forestall a recurrence, a prealarm horn was installed on the system-activity monitor.

Sudden, severe cladding rupture (Feb. 16, '59). While the reactor was being taken to power, a violent increase of the activity of the CO_2 system gave the alarm and the control rods were dropped immediately. The burst-slug detection system didn't have the time to indicate which element was causing the increase in activity; also the temperature of the fuel cells gave no abnormal readings.

The contaminated CO_2 was evacuated in the usual manner through filters, and it was decided to put in fresh gas and take the reactor critical with clean gas to a power level of 5 kw to find the defective element. It was indeed found after 2 hr operation—the necessary time for a complete exploration.

The usual measures were thereupon taken to withdraw the damaged element but at the moment of withdrawal a slight entry of air into the system—which, as is prescribed in the operating procedures was at a slight negative pressure—caused a severe, though localized increased in activity at the CO_2 intake and exhaust manifolds atop the reactor. Apparently the re-entering air ignited the pyrophoric bare, pulverized uranium and thus contaminated the entire system in the vicinity of the damaged element. The fuel cell was removed, but only a part of the uranium came out with the plug.

It was then decided to fill the tube remaining in the core with oil and to take out the tube and fuel rod together in a cask especially constructed for such a circumstance. The excessive contamination required us to unload the reactor completely and to dismantle the collector manifolds, which was difficult owing to the high level of activity on the reactor top.

We took advantage of the situation to change all the tubes and to inspect the calandria vessel after having emptied the heavy water. In an attempt to find the cause of the violent accident that caused the melting of uranium slugs, we proceeded to conduct an autopsy on several other tubes and found deposits of polymerized oil that seem to have been the cause of the accident. After a certain time, solidified deposits of oil had succeeded in forming a plug that blocked the flow of CO_2 in a fuel cell. [Compare recent accident to fuel elements of the Sodium Reactor Experiment (NU, Dec. '59, p. 23, Jan. '60, p. 107) ED.] Nevertheless we couldn't explain very well the violence of the phenomenon. The work of dismantling, of reassembly and of changing all the fuel cells took an entire month. Thanks to the stringent precautions not the slightest trace of contamination was spread in the reactor room.

CONCLUSIONS FOR EL-2

The most frequent incidents involving EL-2 were those caused by cladding failures. In a sense they were deliberate, for we tried to make the fuel elements last as long as possible. The successive jobs of putting the reactor back in service were extremely instructive: they permitted us to perfect procedures for handling contaminated equipment. Moreover the cladding failures that occurred in EL-2 have permitted the service groups responsible for building burst-slug detection systems to improve the precision of their apparatus.

Neutron-Absorption Alignment Chart

By ROBERT G. NISLE, *Phillips Petroleum Co., Idaho Falls, Idaho*

To SELECT an absorbing foil or monitoring wire for the measurement of neutron flux density one must be able to predict the flux depression that results from introducing the foil or wire. To a first approximation the depression* is directly related to the attenuation of a beam of neutrons in passing through the material of the monitor. The alignment chart to the right is based on this relationship. The chart can be expected to give values for flux depressions to an accuracy of about 5%. For instance, a 1.4-in.-dia thorium slug was observed in a reactor experiment (IDO-16419) to produce a flux depression of *52%*; although this combination of variables is outside the range of the nomogram (and hence is an extreme test), an extrapolation of the nomogram yielded a value for the flux depression of *50%*.

Chart Basis

The construction of the chart is based on three equations.

$$\frac{n}{n_0} = e^{-\Sigma_a x} \qquad (1)$$

$$\Sigma_a = \frac{\rho N_0}{A}\sigma_a \qquad (2)$$

$$N = \frac{\rho N_0}{A} \qquad (3)$$

Equation 1 gives the fractional transmission n/n_0 of a beam of neutrons passing through a sample with a macroscopic absorption cross section Σ_a and a thickness of x cm. Equation 2 defines Σ_a in terms of the density ρ gm/cm³, atomic weight A, microscopic absorption cross section σ_a and Avogadro's number N_0. Equation 3 defines N, which can be calculated from the three scales on the right of the nomogram chart.

Although these equations describe the absorption of a beam of neutrons, this chart can also be used to estimate the depression in the neutron flux density. To a first approximation the flux depression is equal to $1 - n/n_0$. This approximation is satisfactory for thin foils. For thick foils we make the assumption that the value of the exponential function for an average thickness x_{avg} can be substituted for the average of the exponential function over the possible neutron path lengths through the material. This is not strictly true, but within the accuracy of the chart it is good enough. This average distance through the solid (for straight lines that cut the surface in two, and only two, points) is given by

$$x_{avg} = \frac{4V}{S} \qquad (4)$$

where V = the volume and S = the surface area.

From Eq. 4 we have the following average thicknesses for the common geometrical forms:

Geometry	x_{avg}
Sphere	$4r/3$
Cylinder	$2r/(1 + r/L)$ or d (when $L \gg r$)
Slab	$2a$ [when $a \ll (S)^{1/2}$]

where r = radius, a = thickness, $d = 2r$ = diameter, L = length of cylinder and S = area of thin slab.

Examples

• *Estimate the flux depression for a 20-mil tantalum foil; σ_a = 21 barns.*

For tantalum we find

$$N = \frac{\rho N_0}{A} = 5.52 \times 10^{22} \text{ atoms/cm}^3$$

$$x_{avg} = 2a = 2 \times 20 = 40 \text{ mils}$$

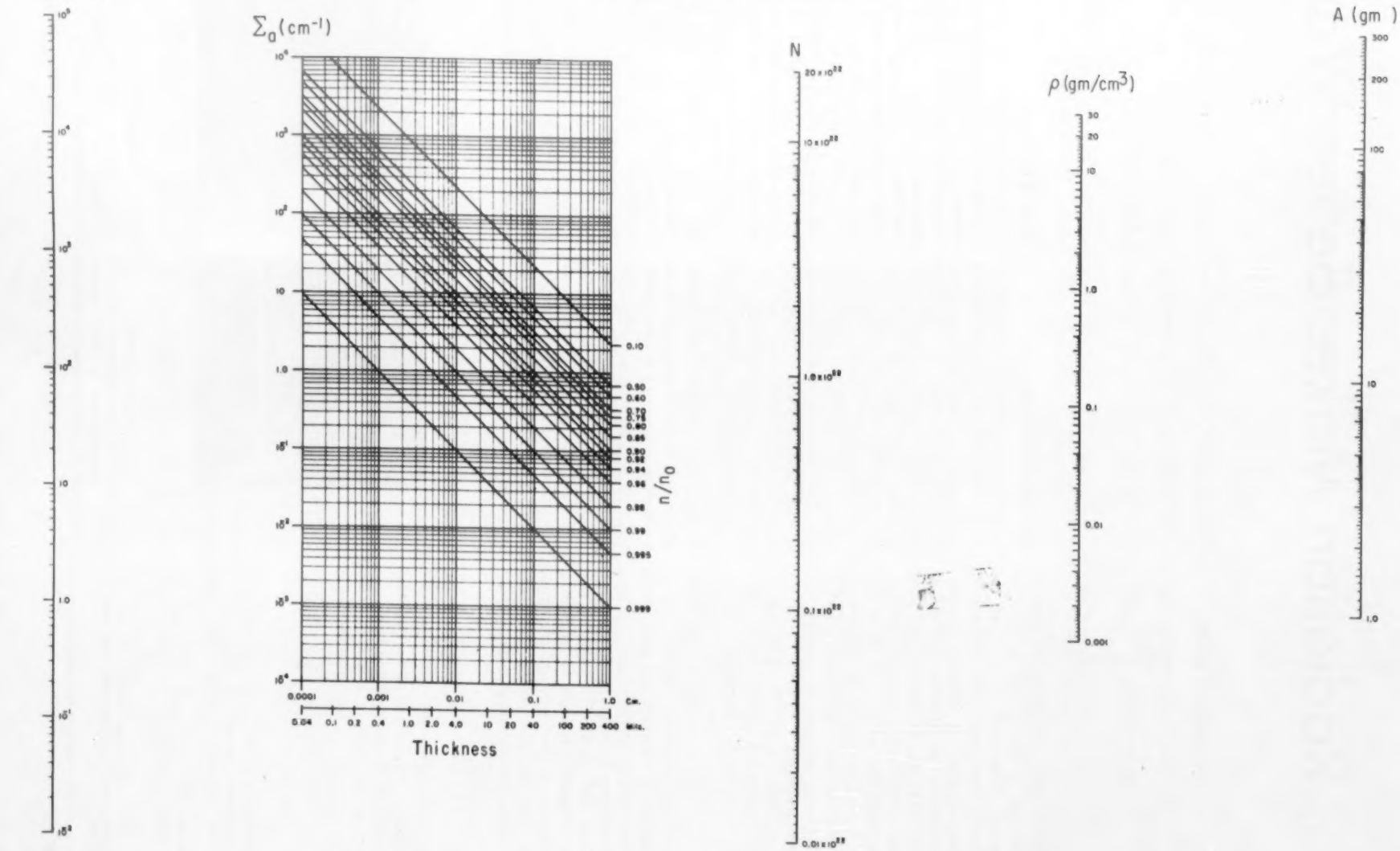
A straight edge joining 21 on the σ_a scale and 5.52 on the N scale intersects the Σ_a scale. This intersection is projected horizontally to meet the vertical line through 40 mils on the thickness scale. These intersect at the n/n_0 line for 0.90. Hence, the flux depression will be about 10%.

• *Find the maximum concentration of a boric acid solution contained in a long cylindrical inert container of 0.5 cm inside diameter that would cause a flux depression less than 15%.*

The thickness $x_{avg} = d = 0.5$ cm. Find the point $n/n_0 = 0.85$, $x_{avg} = 0.5$ cm on the chart. Project this point horizontally to meet the Σ_a scale. For natural boron, $\sigma_a = 755$ barns (neglect the absorption of the hydrogen and oxygen in boric acid). Join the point $\sigma_a = 755$ with the projection on the Σ_a scale just found and extend this line to intersect the N scale at 0.041×10^{22}. Hence, 4.1×10^{20} nuclei/cm³ of boron are required, or 4.1×10^{20} molecules/cm³ of boric acid. The molecular weight of boric acid is 61.84. Connect 0.041×10^{22} on the N scale with 61.84 on the A scale and read 0.042 g/cm³ on the ρ scale. This is approximately 4% by weight in a water solution.

* See p. 78 for a detailed treatment of flux depression by foils and the distinction between flux depression and total flux perturbation.

Neutron Absorption Alignment Chart



Radiation Makes Better Woods

By VLADIMIR L. KARPOV, YURI M. MALINSKY, *L. Y. Karpov Institute of Physical Chemistry, Moscow, USSR*

VASILI I. SERENKOV, RAISA S. KLIMANOVA, *Research Institute of Plastics, Moscow, USSR*

and ANATOLI S. FREIDIN, *Research Institute of Mechanical Treatment of Wood, Archangelsk, USSR*

COPOLYMERS PRODUCED BY nuclear radiation are the subject of much research. There are two important varieties. Graft copolymers are made by grafting chains of different chemical composition or structure to original molecular chains. Block copolymers result from linking chains of different polymers that are mixed in a more random manner. There are many ways to produce these materials, but that of irradiating mixtures is probably the least developed.

Our research has led to two kinds of materials that appear to have valuable properties for commercial use. One is a type of wood in which a monomer is inserted by impregnation and subsequently polymerized. By choosing an appropriate monomer and appropriate conditions of irradiation one can produce unusual strength, dielectric properties and chemical resistance. The other material is made by irradiating mixtures of polystyrene and polyethylene and combines some of the best properties of the two plastics.

POLYMER-WOOD

We have made useful modifications of both hard and soft woods by soaking them in monomers and then irradiating. Radiation polymerizes the monomers and in some instances forms graft copolymers. The modified wood displays many improvements as compared with the original material. Among them are increases in chemical resistance, fire resistance, fungus resistance, strength and dimensional stability; decrease in water absorption; and improvement in dielectric constants.

In contrast to popular kinds of wood-and-plastic combinations (DSP is a Russian-made plywood with plastic interlayers; Delta Wood is a material made by impregnating wood with artificial resin and hardening at high temperature and pressure), the polymer-wood combinations retain fully the cell structure of the wood. The cell structure presents a framework that is filled by the newly formed plastic polymerized inside it.

How It Is Done

The technique has the advantages that it can be performed at room temperature, at atmospheric pressure, without catalysts or initiators and with low-viscosity monomers. Low viscosity facilitates the original impregnation.

By varying the choice of monomer, the extent of impregnation of the fibrous base and the conditions of irradiation, one can produce materials with extremely different properties. We have studied in particular the modification of wood by polystyrene, polymethylacrylate, polymethylmethacrylate and polyacrylonitrile. The most interesting results are observed with polymers that are soluble in their monomers.

Properties of pine wood modified with polystyrene are shown in Table 1. The volume weight of the material increases from 0.46 to 0.61 gm/cm³ when the wood absorbs 20.5% of its weight of styrene and is subsequently irradiated. (Volume weight is the ratio of weight to volume; it differs from true density for

TABLE 1—Properties of Polystyrene-Wood* at Three Radiation Doses

Property	*Absorbed dose (10^6 rads)* 0	15.5	50
Resistance to compression along fiber (kg/cm²)	325	920	1,050
Resistance to static bending (kg/cm²)	845	1,400	1,135

* Pine wood impregnated with 120% of its weight of styrene and irradiated at 80,000 rads/hr.

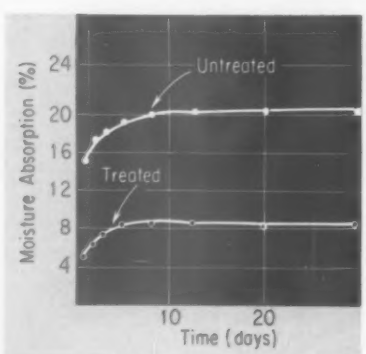


FIG. 1. MOISTURE ABSORPTION is much less in polystyrene-treated than in untreated wood. Exposure was to 95% relative humidity at 15° C and atmospheric pressure

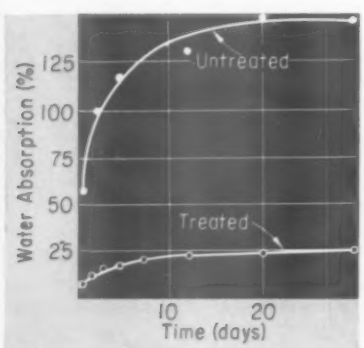
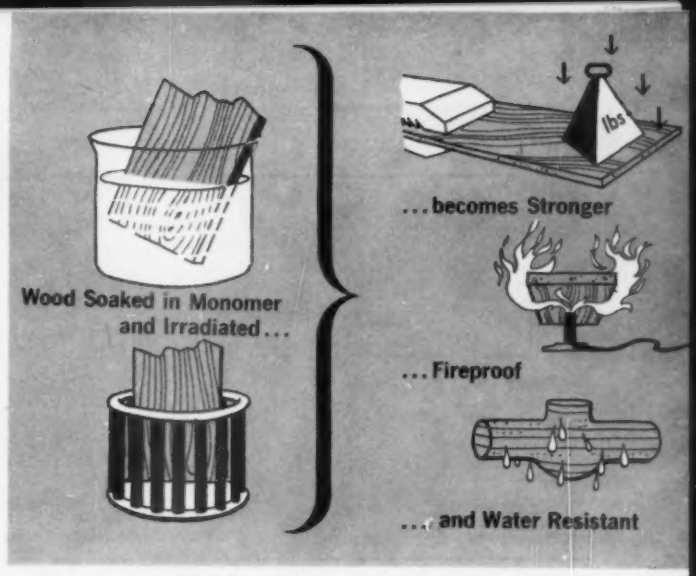


FIG. 2. WATER ABSORPTION is also much less in treated wood than in untreated. Samples were soaked in water at 15° C and atmospheric pressure

and Copolymers



porous materials.) When wood absorbs 120% of its weight of styrene its volume weight increases from 0.46 to 1.0–1.1 gm/cm³. Figures 1 and 2 show the decrease in absorption of water vapor and liquid water for this wood. Maximum water absorption in a 30-day period is not greater than 25%, and the volume increase caused by moisture absorption is only half that of the initial wood.

It can be seen from Table 1 that the greatest improvement of strength corresponds to an absorbed dose of 1.5×10^7 rads. Further irradiation decreases the resistance to static bending as a result of radiation-induced alterations in the wood itself. Dose rate as well as total dose is important.

To understand the effects of large doses we have carried out an extensive study of the effects of radiation on unmodified wood. The box on page 90 and Table 2, which goes with it, describe some of the results of this study.

Usefulness

One use for our polymer-wood has already proved successful. Wood modified with polystyrene was used for casting models, used in metal-casting technology to form cavities of predetermined size and shape in molding earth. After 18 days in molding earth such models hardly change in shape or size. Moreover they absorb only half as much moisture as models that are not processed. They have several characteristics that are superior to those of models protected by other techniques.

In commercial fields we expect these modified woods to find many applications in building, transport, engineering and the electric and radio industry.

Polymerization of monomers by ionizing radiation can be done not only in wood but also in other fibrous materials—textiles, paper, etc.—with considerable alteration of properties. One interesting application is the preservation of museum items and archeological treasures composed of fibrous material.

MIXED POLYMERS

We have also made new polymers by irradiating mixtures of high-pressure polyethylene and polystyrene. The initial components were mixed by rolling at 140° C in weight proportions of 90 to 10, 80 to 20 and 50 to 50. (We use sample designations indicating the percentage of polystyrene. Our three mixtures are, thus, PS-10, PS-20, PS-50.) It is plain that an interaction between the polyethylene and polystyrene takes place with irradiation.

We made samples for irradiation either by applying a pressure of 250 kg/cm² on the surface of the sample and heating to 160–165° C or by molding under pressure at 180° C. Irradiations were performed with a 12,500-curie Co^{60} source (21,000 gram-equivalents of radium) at 20° and 130° C, with and without the presence of atmospheric oxygen.

Samples were tested for tensile strength, elongation and specific-impact strength before and after irradiation. The impact test did not destroy PS-10 or PS-20, either before or after irradiation. Changes of mechanical

TABLE 2—Effect of Radiation on Strengths of Three Woods*

	Dose (10^6 rads)											
	0	*10*		*50*		*100*		*300*		*500*	
Property	*Strength limit (kg/cm²)*	*Strength limit (kg/cm²)*	*Change of strength (%)*	*Strength limit (kg/cm²)*	*Change of strength (%)*	*Strength limit (kg/cm²)*	*Change of strength (%)*	*Strength limit (kg/cm²)*	*Change of strength (%)*	*Strength limit (kg/cm²)*	*Change of strength (%)*
Resistance to compression											
Pine	350	360	0	385	+5.5	350	−4	320	−12.5	250	−33
Ash	520	—	—	—	—	450†	−16.5	410§	−21	—	—
Beech	655	—	—	—	—	570	−18.5	500	−21	—	—
Resistance to splitting											
Pine	75	70	−6.5	57	−24	39	−48	32	−57	22	−70
Ash	150	—	—	—	—	105	−30	100§	−34	—	—
Beech	85	—	—	—	—	—	—	27§	−68	—	—
Resistance to static bend											
Pine	825	800	−3	660	−20	370	−55	250	−70	83.5	−50
Ash	920	—	—	—	—	—	—	230§	−64	—	—

* Dose rate is 10^6 rads/hr except as otherwise indicated. † Dose rate 1.4×10^5 rads/hr. § Dose rate 3.8×10^5 rads/hr.

TABLE 3—Mechanical Properties* of Polyethylene-Polystyrene

	Dose (10^8 rads)																
	0			1			2			3			4			5	
Material	σ	ε	τ	σ	ε	τ	σ	ε	τ	σ	ε	τ	σ	ε	τ	σ	ε
Polyethylene	111	350	—	—	—	—	155	80	—	161	70	—	160	50	—	—	—
PS-10	90	75	—	163	69	—	172.5	65	—	200	54	—	175	45	—	169	40
PS-20	88	62	—	113	35	—	161	23	—	176	20	—	183	20	—	168	15
PS-50	78	57	14	92	10–15	27.2	161	5–7	53.5	—	—	—	162	5–7	61	160	5–7

*σ = tensile strength (kg/cm²); ε = elongation in tension (%); τ = impact strength (kg-cm/cm²). (This test was done according to the Soviet National Standard W-4647-SS.)

properties of the polymers are shown in Table 3.

What Happens?

Chemical procedures have been used to find out what occurs in the irradiation of these mixtures. The quantity of ungrafted and noncrosslinked polystyrene was determined by extracting irradiated samples with toluene for 12 hr in a Soxhlet apparatus—a device that extracts the soluble component of a sample with automatic periodic changes of solvent.

Part of the ungrafted and noncrosslinked polystyrene can not be extracted because it is immobilized in crosslinked polyethylene. Nevertheless, the measurement is adequate for drawing certain conclusions about the interaction of polyethylene and polystyrene during irradiation. In particular, examination of the extract from a PS-10 sample exposed to 6×10^7 rads shows that not only is all of the polystyrene extracted but also 8–10% of the polyethylene.

After the extraction process, three distinct precipitates can be separated from the solvent. The first settles upon cooling. Elementary analysis indicates that it is polyethylene. Then we add methanol in quantities too small to precipitate polystyrene. The precipitate that settles appears by elementary analysis to be a product of interaction between polystyrene and polyethylene. Another adding of methanol brings down a third precipitate. Its elementary analysis is very close to that of polystyrene.

Property Changes

The interaction is also confirmed by thermo-mechanical tests of irradiated and nonirradiated samples of PS-10, PS-20 and PS-50. For example, samples of PS-10 and PS-20 irradiated to $5–7 \times 10^8$ rads display a slightly greater modulus of elasticity than pure polyethylene. Only interaction during irradiation accounts for the increase.

Irradiation causes a large change in the response of the mixtures to heat. Instead of a change to a viscous material, which is displayed by the nonirradiated mixtures, irradiated samples change to a highly elastic material at a temperature 35–40° C higher. We have also examined the thermal stability of PS-10, PS-20 and PS-50 irradiated to 10^9 rads in air by heating them to 250° C for 4–6 hr. In all cases a change of color occurred but no change of form.

Examination of the solubility of irradiated pure polyethylene and the polyethylene-polystyrene mixtures shows that polystyrene stabilizes the polyethylene in such a way as to reduce cross linking.

Irradiated Melts

We had no success in our attempts to produce the polyethylene-polystyrene copolymers by irradiating melted mixtures. We irradiated samples of PS-10, PS-20 and PS-50 at 130° C. The purpose was to achieve a closer combination of polystyrene and polyethylene, reduce the viscosity of the medium and make conditions more favorable for interaction.

Visual observation shows that at this temperature the mixtures change to homogeneous and transparent melts. During irradiation, however, intense gas formation produces porous materials that do not have the useful properties of those produced at lower temperatures.

How to Use Them

The polyethylene-polystyrene mixtures irradiated at room temperatures become new polymeric materials with improved strength and thermal stability up to 250° C. These materials are not amenable to known processing techniques; the improvement is only applicable for previously shaped products.

Materials of this kind may find application in radio engineering and electrical technology and in situations requiring improved radiation stability in products usually made of polyethylene and similar polymers.

How Radiation Affects Wood

Development of useful polymer-wood combinations followed extensive research on the effects of radiation on wood and the lignin-carbohydrate complex of which it consists. Table 2 shows the doses that lead to significant strength decrease in various kinds of wood. It is apparent that these doses are much higher than those necessary for modifying wood by radiation polymerization.

Changes in mechanical properties of irradiated wood are caused by radiation-chemical processes. These result in higher solubilities in water, mainly as a consequence of breaking polysaccharide macromolecules into products of smaller molecular weight.

Radiolysis affects first the hemicelluloses—among these the pentosans—and second, cellulose. Lignin is the most radiation-resistant component protecting carbohydrates from radiolysis. In order of increasing radiation resistance the polysaccharides are as follows: araban, xylan, mannan, galactan, cellulose.

Lignin is responsible for the resistance of wood to compression, and cellulose and the hemicelluloses make it resistant to splitting and bending stresses. This explains why our irradiated wood has greater resistance to compression and less to bending and splitting than unirradiated samples.

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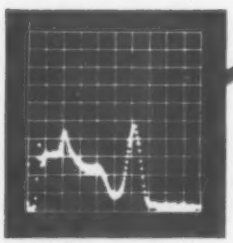
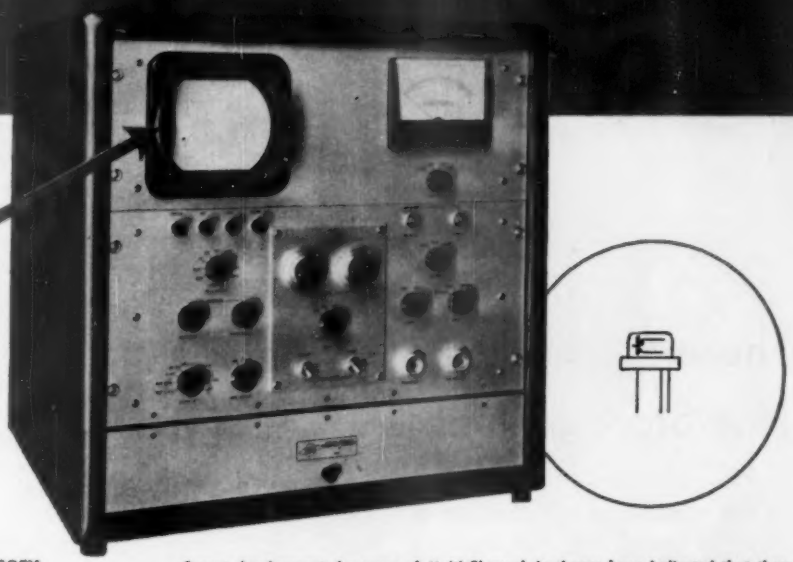


Cesium 137 spectrum photographed from CRT display of Model 34-8.



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The purpose of this accessory would be to provide the data storage and correction function with a minimum of external equipment. A system to accomplish these functions is now being developed by RIDL for use with the Model 34-8 Transistorized 200 Channel Analyzer. This system is intended to be used to substract arbitrary amounts of standard spectra from composite samples, to remove large peaks contributed by unknown amounts of known radiation and to reveal significant amounts of unknown radiation.

The majority of the necessary circuitry has already been incorporated into the basic Analyzer in order to minimize the overall cost of such a system. The principle external accessory to the Analyzer would then be a magnetic storage element such as an endless magnetic tape or a magnetic disc-type recorder. The pulse height analyzer is used to provide the standard samples for the magnetic tape and performs the arithmetic operations required for the subsequent subtraction of these samples from the unknown data.

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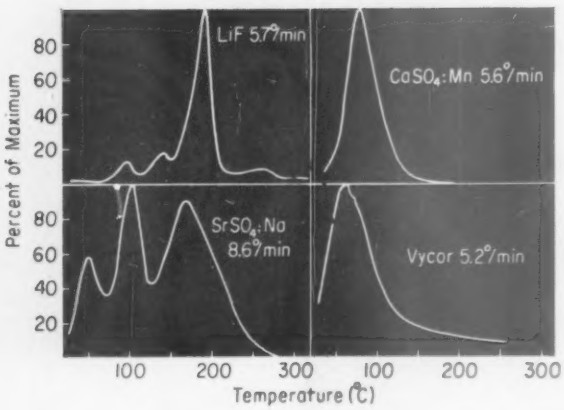


FIG. 1. GLOW CURVES of thermoluminescent solids (exposed to 35-kv X-rays)

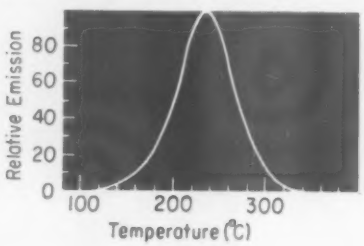


FIG. 2. GLOW CURVE of CaF_2:Mn

Thermoluminescent Dosimeter Has Storage Stability, Linearity

By J. H. SCHULMAN, R. J. GINTHER, R. D. KIRK and H. S. GOULART
Dielectrics Branch, Solid State Division
U. S. Naval Research Laboratory, Washington, D. C.

A thermoluminescent material, CaF_2:Mn, has been developed at this laboratory that satisfies the objections to previous such materials for dosimeter use. Its energy-storage stability, linearity of response and dose-rate independence offer the possibility of replacing the personnel film badge by a cheaper, simpler, more conveneint device.

Film badges have several inherent disadvantages: They require careful development and measurement. Shelf life is limited. Multiple films are necessary for adequate dose-range coverage. And because of the facilities and manpower required, many laboratories contract for an outside service.

Thermoluminescence had been suggested several years ago (*1, 2*) for measuring ionizing-radiation dose, and the method has been applied to special dosimetry problems (*3*). However, thermoluminescent dosimeters have never been considered suitable for health physics monitoring applications. To be useful for this purpose, it is necessary that a dosimeter detect doses as low as 50 milliroentgens of ~1.25-Mev gamma rays which have been delivered up to one month prior to the dose reading. Previously used thermoluminescent materials (LiF, Al_2O_3, $CaSO_4$, Vycor, etc.) have been unsatisfactory for this purpose either because of inadequate sensitivity (*1, 2*) or because a substantial fraction of the stored energy was lost quite rapidly merely on standing at room temperature (*1, 2, 4*).

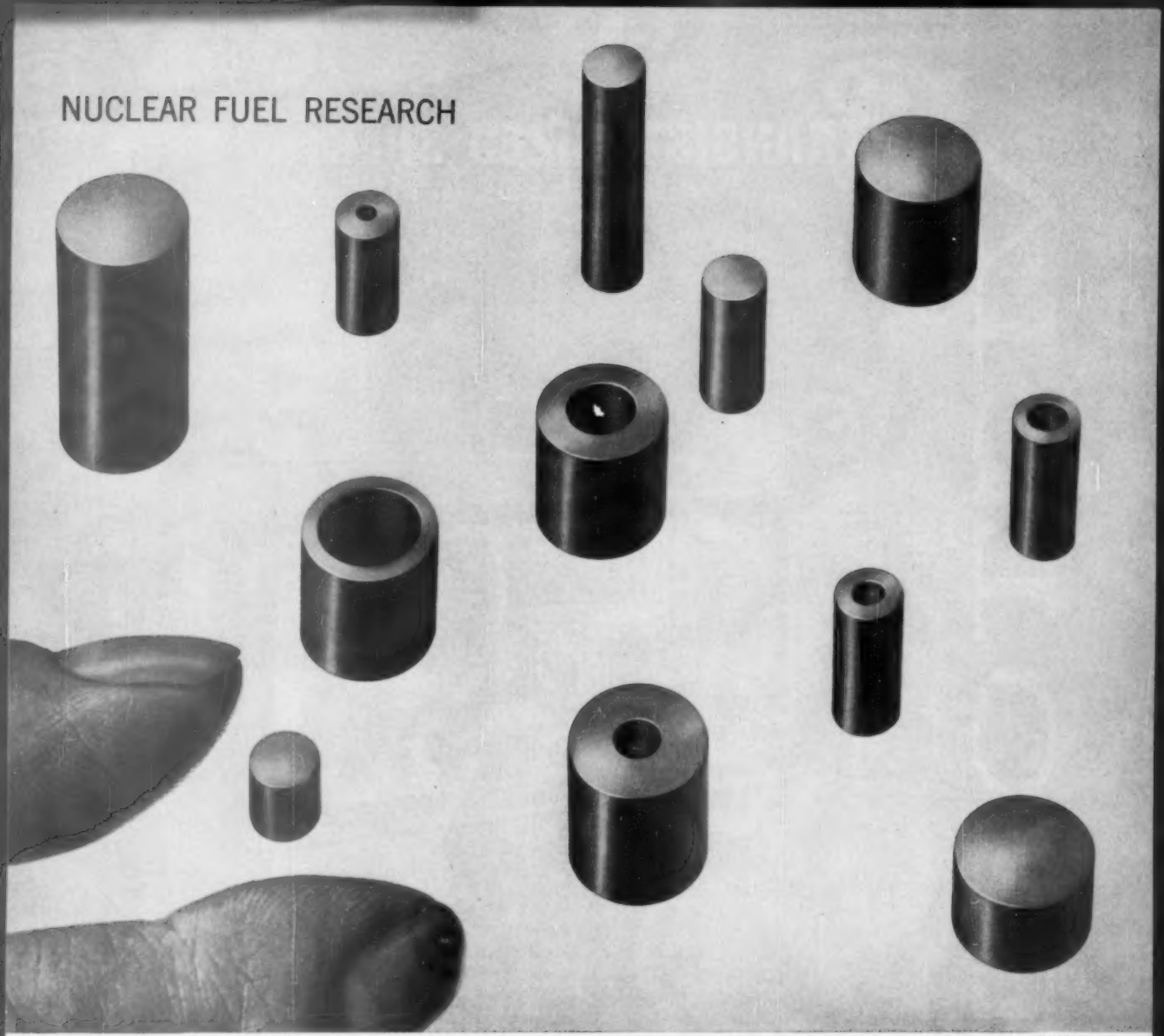
It now appears that a CaF_2:Mn phosphor developed by Ginther and Kirk (*5*) satisfies dosimetry requirements.

INCREASED SENSITIVITY, decreased storage effect and good dose-indication stability are provided by another, new CaF_2: Mn dosimeter at NRL. The phosphor is coated on a graphite square, which is provided with electrical leads and sealed into an evacuated housing with a glass window. Dose determination is made in 30 sec by heating the graphite electrically and observing the glow with a photomultiplier tube. This design can detect 2.5 mr of Co^{60} gamma radiation—and doses up to at least 10,000 r are measurable with the same device. The "pickup" of spurious glow has also been reduced by this arrangement—12-day room-temperature storage resulting in an increase equivalent to a 30-mr dose. Stability of the dose indication under these same conditions is good, doses of 100 mr and 10 r both reading 90% of their initial value after overnight storage and then losing 1% per day for the next 12 days. Performance of these devices will be reported in a separate publication by J. H. Schulman, F. H. Attix and E. J. West.

Principles of Method

In thermoluminescence dosimetry, a luminescent solid stores energy by trapping electrons that have been freed by radiation at imperfections in the solid. When the phosphor is heated, the electrons are ejected from their traps and return to their ground states with the emission of light. The amount of light is proportional to the dose.

Thermoluminescence is best studied by means of glow curves—curves of brightness as a function of temperature. The phosphor, after exposure to an



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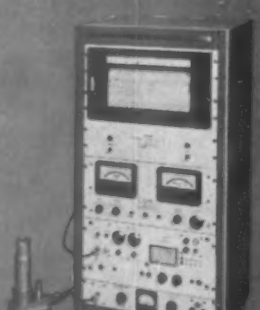

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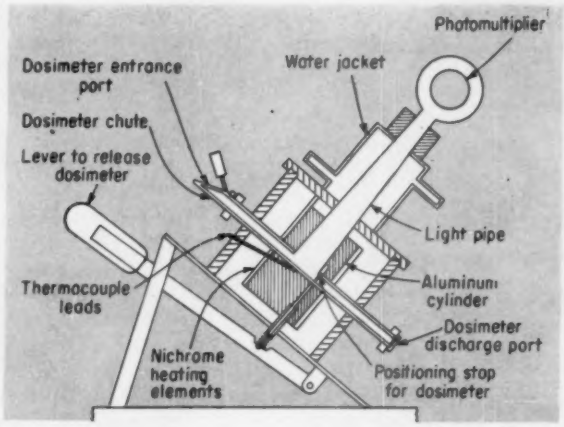


FIG. 3. DOSE-MEASURING APPARATUS uses light-tight furnace and 1P21 photomultiplier

exciting source, is heated in the dark at a constant rate of temperature increase. As the temperature is raised, the luminescent glow reaches a maximum and then, when all the trapped electrons are expelled, drops to zero. The temperature range over which the glow occurs depends on the energy with which the electron is bound in its trap (trap depth). If the trap depth is small, the glow peak will occur at low temperatures—sometimes below room temperature. If there are several types of trapping imperfections, the glow curve will consist of a corresponding number of glow peaks. Glow curves of this type are shown in Fig. 1 for some thermoluminescent solids that have been considered (*1–4*) for dosimetry. In contrast, the glow curve of the CaF_2:Mn phosphor (Fig. 2) exhibits a single peak at approximately 240° C, corresponding to a trap depth of ~1 ev.

Although the trap depth is a characteristic of the imperfection in the phosphor, the temperature and height of the glow peak depend somewhat on the rate of heating. Thus, the glow can be emitted at a low level over a long period of time by heating the phosphor slowly or as a sharp burst of high-intensity light by very rapid heating. However, the total light emitted over the glow interval is essentially independent of the heating rate. Generally, the area under the glow peak should be used as a measure of dose, since variations in the heating rate would have little influence on this quantity. Nevertheless, under reproducible conditions of heating, the peak height may serve as an adequate measure of dose.

Two features of thermoluminescence dosimetry should be pointed out. First, the process of reading the dose necessarily erases the dose indication; however, a permanent record can be made by recording the glow curve. Secondly, the signal depends on the dosimeter size and configuration, the heating rate (if peak height is the measured quantity), the efficiency of the light-collecting system and the photomultiplier sensitivity. Like most

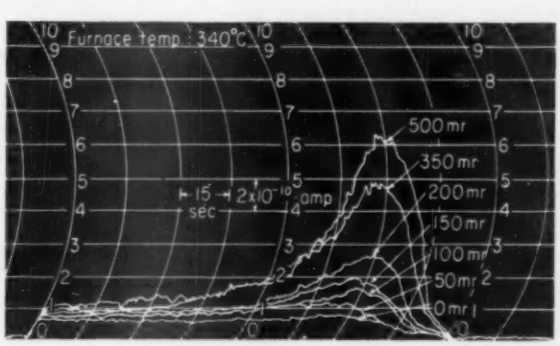
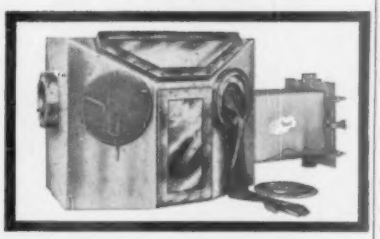


FIG. 4. GLOW-CURVE RECORDINGS OF CaF_2:Mn for various doses

for work in a controlled atmosphere



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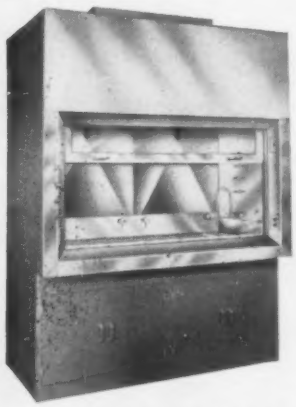

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dosimeters, the thermoluminescent dosimeter is not an absolute device; it must be calibrated against known standards.

The principal disadvantage of the CaF_2:Mn phosphor is that it exhibits "predose" thermoluminescence, i.e., a thermoluminescent glow that arises without exposure to radiation (*5*). This predose thermoluminescence is variable and equivalent to at least 300–400 mr. The effect arises, at least in part, from the sensitivity of the powder to mechanical handling, i.e., the phosphor is extremely tribothermoluminescent. The predose thermoluminescence can be greatly reduced by rigidly mounting the phosphor powder. When this is done, doses of the order of 50 mr of Co^{60} radiation can be detected with very simple apparatus.

Experimental

The prototype dosimeter used in the present experiments consists of a 1-in.-diameter disk of $\frac{1}{16}$-in.-thick copper, one face of which is coated with CaF_2:Mn phosphor in a rigid mounting.

The copper face is first covered with a layer of commercial, opaque, white, copper-enameling glaze by conventional firing techniques. A second layer, consisting of a mixture of one part by weight of CaF_2:Mn with two parts by weight of a clear sodium lead silicate glaze, is then applied by the same technique. The phosphor is thus bonded to the copper backing plate and firmly embedded in a protective layer of glass. Good coverage of the copper was found to require two coats of the opaque white and two coats of the phosphor-bearing glaze, making a total of four firings. The experiments were conducted with about 25 hand-fabricated dosimeters, with sensitivities within ±15% of the average value. Better reproducibility is clearly possible by more standardized and automatic fabrication techniques.

The apparatus used to measure the dose is shown in Fig. 3. It consists of a small light-tight furnace with a simple means for inserting and removing the dosimeter, and a 1P21 photomultiplier tube that views the active surface of the dosimeter. The dosimeter slides down the inclined guide and is arrested by a mechanical stop at the center of the furnace. The thermoluminescent light is directed by a light pipe to the

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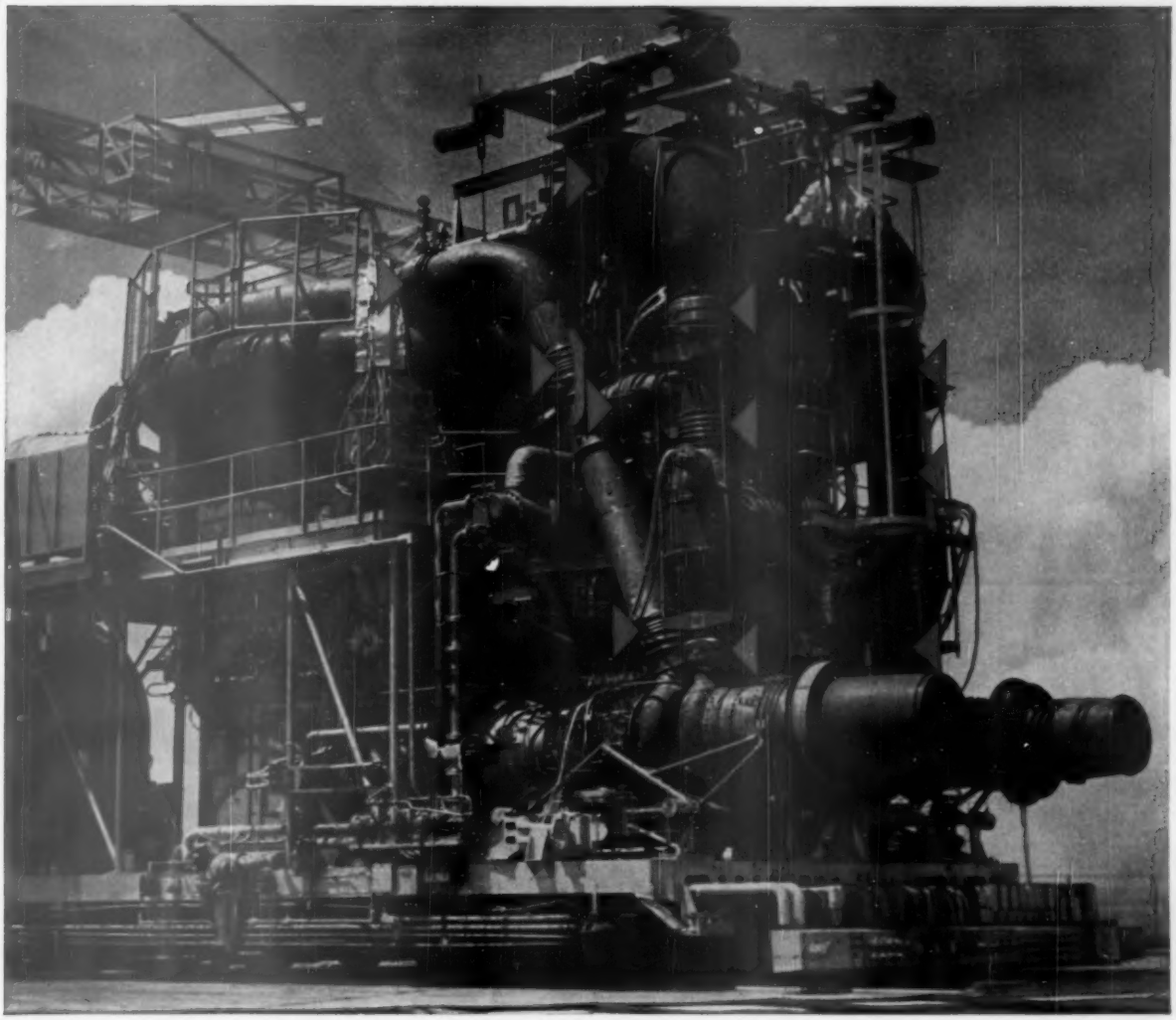

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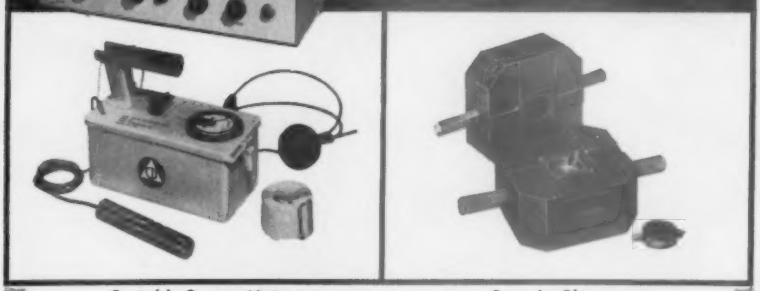

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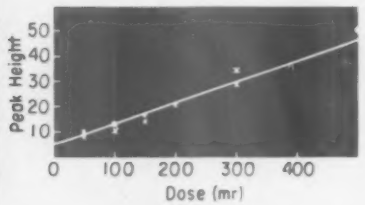


FIG. 5. GLOW-PEAK HEIGHTS for CaF_2:Mn

photomultiplier tube, which is provided with a water jacket to keep it cool. A suitable operating temperature for the furnace was 340° C. The dosimeters are heated quite reproducibly (but not at a uniform rate, of course) so that the peak of the brightness-vs-time curve occurs at about 30 sec after insertion. The heating is continued for 2–3 min to make sure the phosphor is "exhausted." By tripping a lever, the mechanical stop is then moved; the dosimeter slides out of the furnace and is ready for reuse as soon as it is cool.

The photomultiplier output was amplified by a General Radio Type 1230-A d-c amplifier and recorded on a 1-milliampere Esterline-Angus recorder.

Results and Discussion

Superimposed tracings of records obtained in one of the series of experiments are shown in Fig. 4. Figure 5 is a plot of the glow-peak heights obtained in a more extended series of runs. It can be seen that a dose of 100 mr more than doubles the predose thermoluminescence peak; that 50 mr can be detected even with the simple

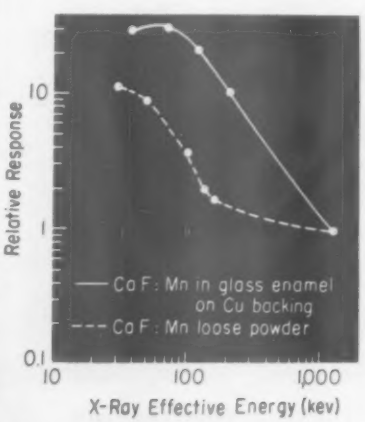
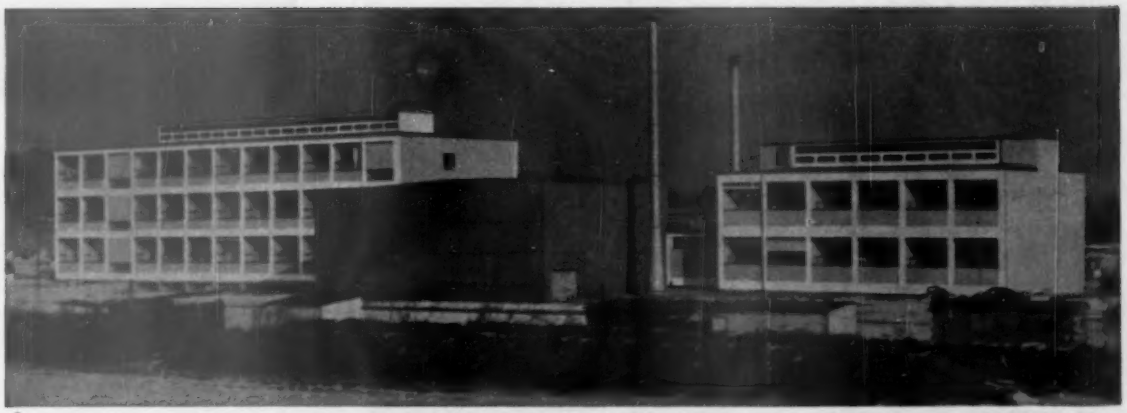
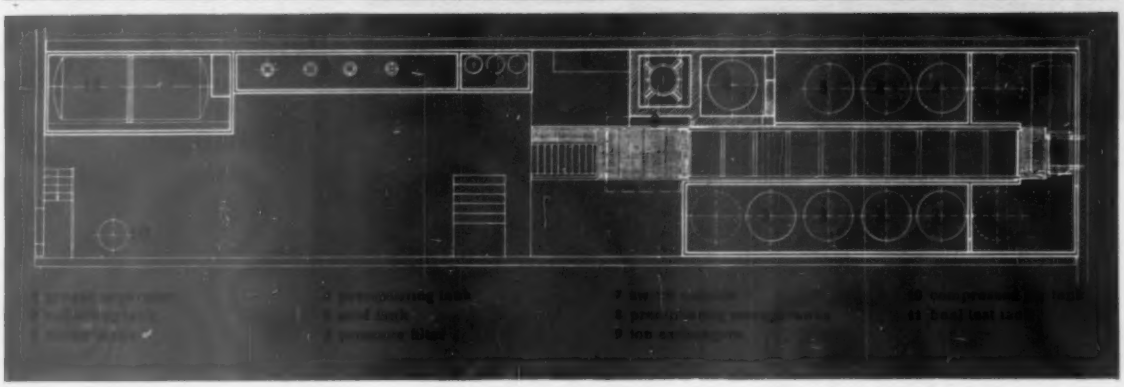


FIG. 6. ENERGY DEPENDENCE of powdered and of mounted CaF_2:Mn





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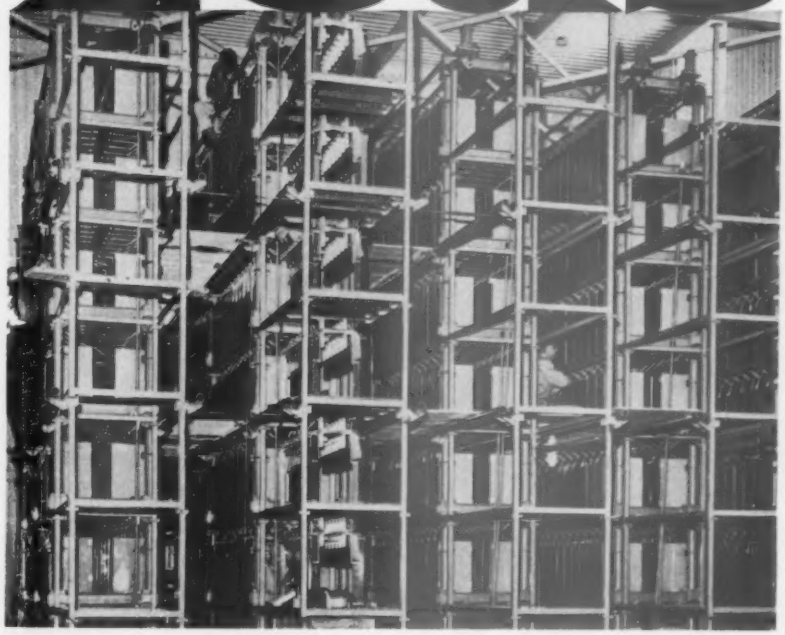

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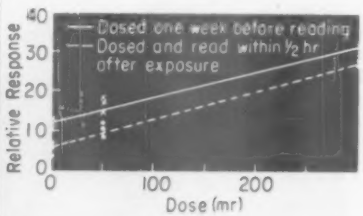

FIG. 7. EFFECT OF STORAGE on luminescence of dosed CaF_2:Mn dosimeters

arrangement employed; and that the response is linear up to at least 500 mr. Tests of >500 mr were not made on the present device, but earlier work (*5*) had shown that CaF_2:Mn powder responds linearly with dose, at least over the range 1 to ~700 r.

The energy dependence of the dosimeter, measured with radiation incident perpendicularly on the sensitive coating of the disk, is shown in Fig. 6 along with that of the unmounted powder. The more severe energy dependence of the glass-enameled disk arises from the composition of the glaze, which contains a considerable proportion of lead. To make the dosimeter energy independent, some means of selective shielding is required, such as has been employed in other solid-state devices (*6*, *7*). On the other hand, if the dosimeter is to be used only for radiations near its peak sensitivity, doses of the order of 2 mr should be detectable.

Dosed samples that had been stored for one week in the dark at room temperature showed no loss in dose indication within the present limits of error. The observed storage stability agrees with earlier results obtained at higher doses with the unmounted CaF_2:Mn powder (*5*). However, after a week's storage, the background thermoluminescence had increased by an amount approximately equivalent to the signal from a 50-mr dose. Stored dosed samples showed an appropriate increase in thermoluminescence over this acquired background. This is illustrated in Fig. 9. In practice, if this behavior cannot be eliminated, the predose background can be obtained by runs on undosed "control" dosimeters that are set aside for this purpose each time the dosimeters are issued for use.

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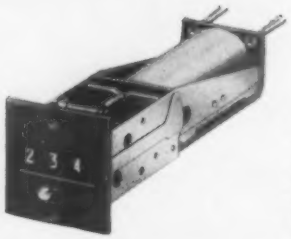

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sensitive to mechanical treatment. Thus, if the dosimeter surface is rubbed or scratched, an appreciable false thermoluminescence signal may be obtained. Ordinary transportation and handling, however, have little effect on the mounted phosphor, in contrast to the extraordinary sensitivity of the loose powder to slight disturbances (*5*). In any practical dosimeter design, the sensitive element will have to be mounted in a case to prevent abrasion or rubbing while it is being worn.

Prolonged exposure of a dosed dosimeter to daylight will reduce the dose indication. Exposure of an undosed dosimeter to intense visible light produces no spurious thermoluminescent signal. No difficulties are encountered in making readings on dosed or undosed dosimeters in a normally well-lighted room. The long-term "bleaching" effect of light will clearly pose no operational problem if the previously mentioned protective case for the dosimeter is made from an opaque material.

Further Work Needed

Further development appears necessary in the following areas: lower atomic number glazes and supports; increased loading of the glaze with the sensitive phosphor; coating of wire-gauze supports that can be electrically heated to make the reading; use of a fired ceramic disk of the phosphor; encasing and shielding; other possible configurations of the dosimeter; and further improvement or simplification of the reading instrument.

* * *

The authors are indebted to Frank H. Attix of the Dielectrics Branch, Solid State Division, for performing the radiation exposures involved in the energy-dependence study and for other help in connection with the irradiation of samples.

BIBLIOGRAPHY

1. F. Daniels, W. P. Rieman. Univ. of Wisconsin, Dept. of Chemistry, Final Report, "The Thermoluminescence Dosimeter," contract DA-18-108-CML 3069 (1954)
2. W. Kossel, U. Mayer, H. C. Wolf, *Naturwissenschaften* **41**, 209 (1954)
3. H. Burger, J. Lehmann, U. Mayer, *Naturwissenschaften* **41**, 209 (1954)
4. D. A. Patterson, H. J. Friedman, *Opt. Soc. Am.* **47**, 1136 (1957)
5. R. J. Ginther, R. D. Kirk. Thermoluminescence of CaF_2:Mn and its application to dosimetry, Report of NRL Progress, p. 12 (1956)
6. J. H. Schulman, R. J. Ginther, C. C. Klick. Dosimetry of X-rays and gamma-rays by radiophotoluminescence, Report of NRL Progress, p. 7 (1952)
7. J. H. Schulman, W. Schurcliff, R. J. Ginther, F. H. Attix, NUCLEONICS **11**, No. 10, 52 (1953)

High-Purity Water Made Possible with Nalcite Ion Exchange Resins

Dresden Boiling Water Reactor System has Unusual Demineralization Needs

Water purity in a degree not even considered a few years ago is required at the Dresden Plant of Commonwealth Edison Company in Northern Illinois. Nalcite Ion Exchange Resins have been chosen for the condensate high flow, reactor cleanup, and waste treatment demineralization units, one of which has an unusual system for removal, regeneration and re-placement of exchange resins.

Condensate High-Flow Demineralizer

2,800 gpm condensate, returning to the reactor from the turbine condensor, passes through the primary system demineralizer at flow rates of 70 gpm/sq. ft. of bed area. This demineralizer is designed to remove more than 1,000 lbs. of dissolved and suspended impurities from the condensate each year.

Resin Removed for Regeneration

To prevent cross-connections between the reactor and regeneration piping, equipment was developed for external regeneration of the ion exchange resins. This is accomplished by semi-fluid pressure transfer.

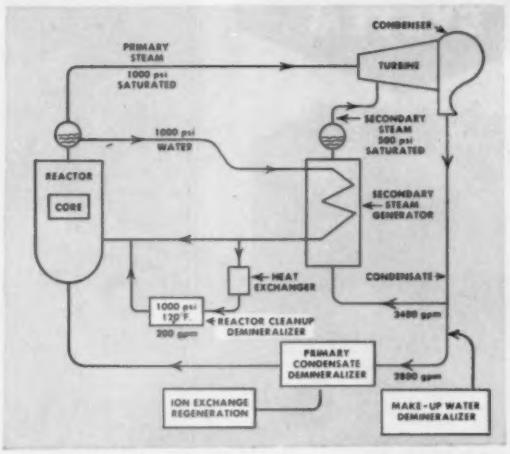
Nalcite HCR-W and SBR-P in the primary condensate demineralizer have the high degree of sphericity and ion exchange ability essential to high flow rate service at minimum pressure drop. They also have the resistance to attrition which permits resin transfer from the demineralizer to separate regeneration units and back, repeatedly . . . without measurable bead breakage.

Reactor Cleanup Demineralizer

The reactor cleanup demineralizer on the return side of the secondary steam generator system handles 200 gpm condensate at 1000 psi, 120° F. On-line and standby units have flow rates of 10 gpm/sq. ft. of bed area. Exhausted resins are radioactive, and are replaced with new resins, rather than regenerated.

Waste Treatment Demineralizer

Radioactivity in wastes is concentrated by the waste treatment demineralizer. Exhausted resins are radioactive and are sluiced from the units and prepared for disposal.



Simplified diagram of the Dresden Boiling Water Reactor steam condensate system. Nalcite resins are used in condensate high flow, reactor cleanup and waste treatment demineralizing units.

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Very small quantities of make-up water are required, due to painstaking design to eliminate condensor leakage, and other system losses. Conventional demineralizers, followed by mixed-bed polishers, provide make-up water.

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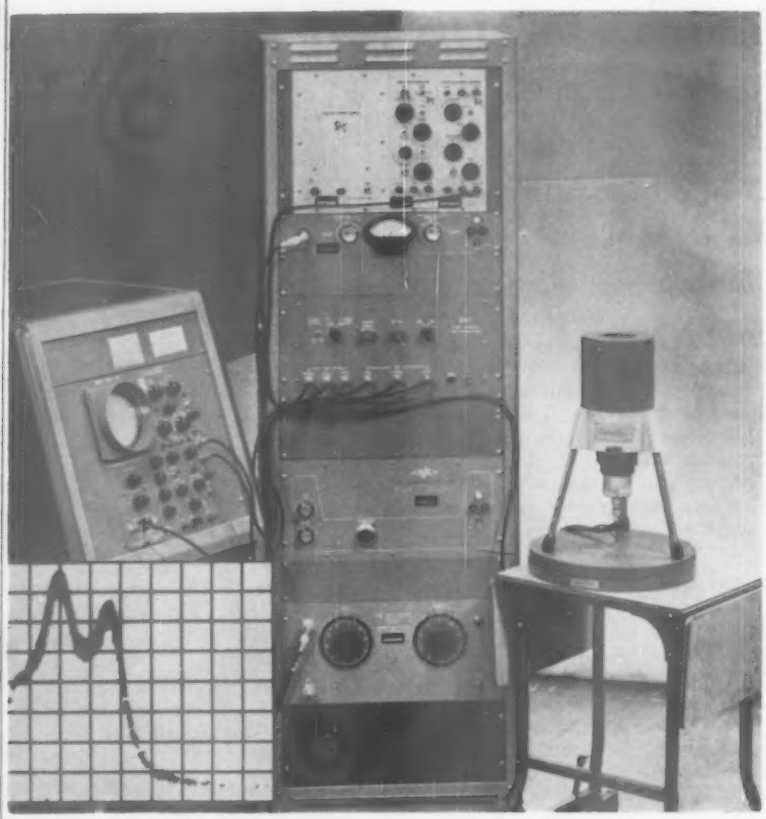

Electronic Display for γ-Spectra

GAMMA-SPECTRAL DATA can be collected and displayed electronically with Hughes Memoscope model 104 and suitable components, as described by M. E. Jacobs (GAT-T-586, Technical Div., Goodyear Atomic Corp., Portsmouth, Ohio). Spectrum is swept electronically in synchronization with oscilloscope sweep, giving good enough resolution to identify a number of radioisotopes. Method is fast, which is important if counting rate is changing. Component circuits include National Radiac SC-2 scintillation head with SW-2 well-type NaI crystal; Baird-Atomic model 312 supply, model 215 amplifier and model 510 pulse-height analyzer (converted to automatic sweep); Tektronix type 162 wave-form generator to furnish analyzer and oscilloscope sweeps; data-processing panel which makes pulse and sweep source and receivers circuits compatible; and Memoscope. Spectrum shown is for thick sample of enriched UF_6 with peaks at 0.093 and 0.18 Mev (vertical integrating time constant is 2 sec; counting rate is 1,000–150,000 cpm with 1-volt window width)

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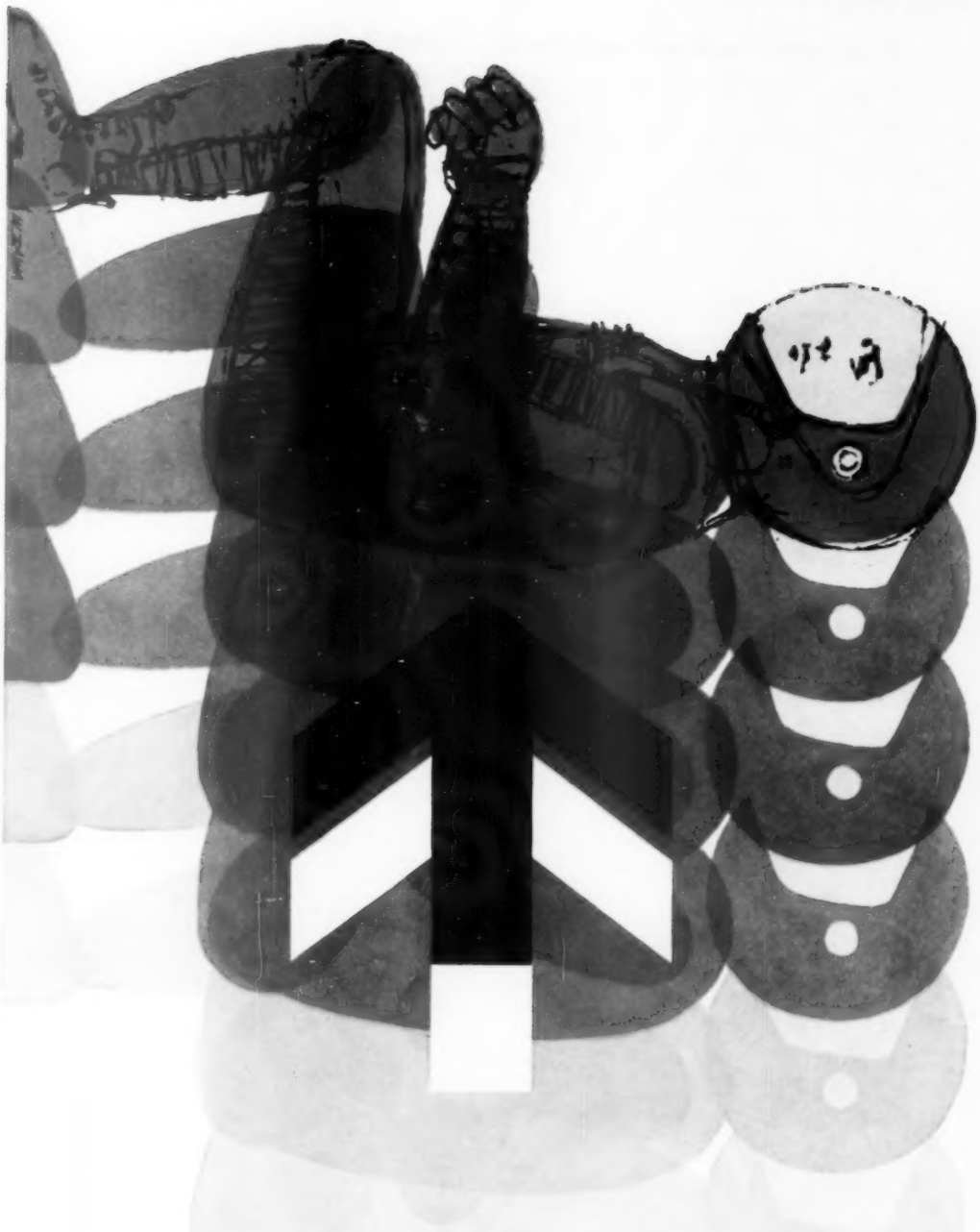

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U Enrichment Can Be Checked by Gamma-Ray Spectrometry

By L. A. SARKES and N. L. MacKINNON
M & C Nuclear, Inc., Attleboro, Massachusetts

Display of the gamma spectrum of a uranium sample on an oscilloscope screen provides a fast, visual way to determine if the sample is natural or enriched. By replacing the oscilloscope with a scaler, we will probably be able to measure the enrichment quantitatively.

The U^{235} and natural-uranium spectra can be easily distinguished, as shown by the typical experimental curves plotted in Fig. 1. Two intense U^{235} peaks appear at 92 and 184 kev, and a third peak of lesser intensity at 143 kev. The one distinct photopeak (90 kev) associated with the natural uranium spectrum is actually due to Th^{234} and U^{235}.

Our gamma spectrometer uses a NaI(Tl) crystal and a Du Mont 6292 photomultiplier. A well-type crystal is used for chopped, melted or liquid samples and a solid crystal for larger samples. For visual display, the amplified detector output is fed into an internally triggered oscilloscope (Tektronix model 545) having a sweep time of 0.1 μsec/cm. After adjusting linear-amplifier gain and selecting a proper rise time, the pulse-energy distribution can be spread across the oscilloscope screen. Pulse height is approximately proportional to gamma-ray energy.

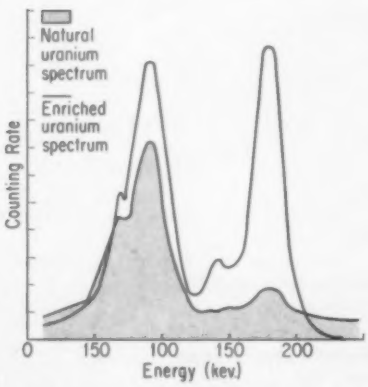


FIG. 1. GAMMA SPECTRA of U^{235} and natural uranium were obtained with solid NaI(Tl) crystal. Data recorded with 1.5-volt channel width; background above bias, ~20 kev, was negligible because of adequate shielding. Resolution of 184-kev peak is ~14%

FIG. 2. OSCILLOGRAMS of spectra of U^{235} (top) and natural uranium (bottom). Broad, intense bands show photopeaks clearly

Figure 2 shows U^{235} and natural-uranium spectra as they appear on the oscilloscope screen. Here, as in Fig. 1, the spectral difference is clearly visible.

Enrichment Determination

We are currently investigating the application of spectrometry to determining enrichment over a wide range of values. The integral counting method is used to obtain integral bias curves for NBS standard samples of various enrichments.

Two counting methods were used: 1-gm solid uranium samples with a solid 1½ × 1 in. NaI(Tl) crystal and liquid samples (5 mg uranium in 5 ml solution) with a 1¾ × 2 in. well-type crystal. In both cases, the output of a Baird-Atomic model 510 single-channel pulse-height analyzer was fed to a Baird-Atomic model 134 glow-tube scaler. The base line was set to correspond to the dip in the spectral curve (Fig. 1) between the small 143-kev peak and the 184-kev peak with a 7-volt channel width. Thus, only the 184-kev U^{235} gammas were counted. With these settings, the background averaged 10 cpm. The counting rate averaged 80,000 cpm for the U^{930} solid sample and 1,200 cpm for the liquid sample.

In determining the enrichment, the 93.27-wt %-U^{235} sample (U^{930}) was used as a standard. The enrichment of the remaining samples was determined by the ratio

$$93.27 \times \frac{\text{(counting rate of sample)}}{\text{(counting rate from 93.27)}}$$

The results for the two methods are given in Tables 1 and 2. The better correlation with the liquid samples was probably due in part to the constant geometry between samples.

Instead of using the U^{930} as a standard, a plot of counting rate versus enrichment could be made and used as a standard curve for a given total weight of sample.

* * *

The authors gratefully acknowledge the technical assistance of Oscar Nietzel and G. LePage.

TABLE 1—Solid Samples; Solid NaI (Tl) Crystal

Sample number	Composition (wt % U^{235})	
	NBS value	Measured value
U^{930}	93.27	Used as standard
U^{900}	90.10	90.6
U^{850}	84.99	86.0
U^{200}	19.80	19.1
U^{050}	4.95	3.85
U^{030}	3.01	2.46
U^{020}	2.01	1.89
U^{015}	1.51	1.64

TABLE 2—Liquid Samples; Well-Type Crystal

Sample number	Composition (wt % U^{235})	
	NBS value	Measured value
U^{930}	93.27	Used as standard
U^{900}	90.10	89.6
U^{850}	84.99	84.9
U^{200}	19.80	19.3
U^{050}	4.95	4.76
U^{030}	3.01	3.08
U^{020}	2.01	1.97
U^{015}	1.51	1.13

Sioux Falls Superheat Design Takes Final Form

Allis Chalmers' Sioux Falls reactor—this country's first reactor with a nuclear superheater—presents a superheater design which is conservative enough to be built with existing technology but which, even so, will run at a fuel cost only 4% higher than that for an oil-fired superheater. The final feasibility report looks forward to cutting this cost in half by switching from fully enriched U fuel to a low-enrichment fuel. The table gives the up-to-date reactor parameters.

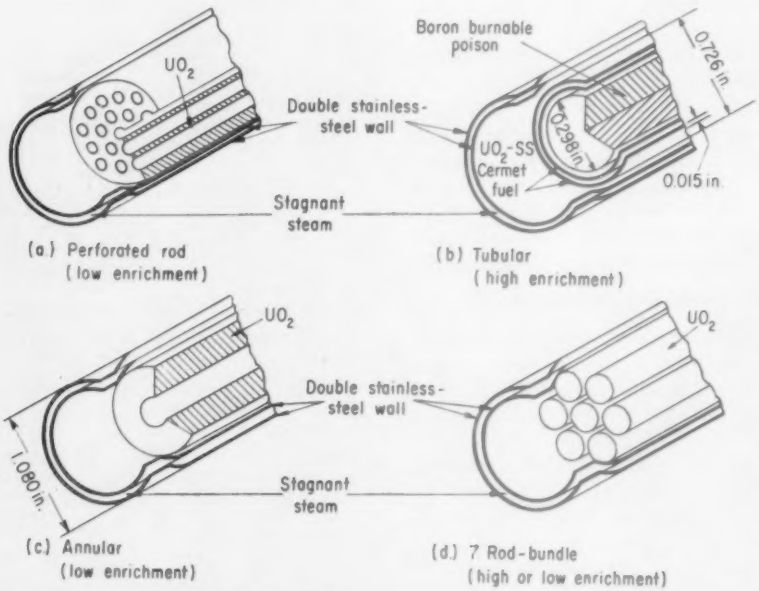
The reactor core consists of a central superheater region surrounded by an ordinary boiling region. Steam formed in the boiling region at 489° F goes up through a moisture separator and then down through the cluster of special fuel elements that forms the superheater section. It exits to the turbine at 825° F and 540 psig. Although these conditions are still relatively low by modern steam standards, they are high enough to begin to partake of some advantages, such as elimination of moisture in the turbine.

Superheater Element

The fuel element for the superheater section (in the first reference design) is an assembly of two concentric fuel tubes surrounding a cylinder of burnable poison material (see *b* in figure below). The fuel is in the form of 93% enriched UO_2-ss cermet, 0.015 in. in thickness. (The burnable poison is necessary with the fully enriched fuel to prevent a substantial shift in the power ratio with burnup between the superheater and boiling regions.)

Allis-Chalmers feels that the tubular configuration offers the use of a fuel with proven fabrication technology and high-burnup experience. Both the maximum temperature and core pressure drop are reasonable.

Eventually the tubular element will give way to a configuration that uses less-expensive low-enrichment fuel. Three low-enrichment elements that are under consideration but which require more development are shown as *a*, *c* and *d* in the figure. The annular type (*c* in figure) would have an orificed flow annulus to equalize the two surface temperatures. It has the advantage of simplicity (only one fuel piece per flow tube) but its maximum surface temperature is excessive and the tech-



SUPERHEATER FUEL-ELEMENT CONCEPTS; configuration b is that chosen for Sioux Falls reactor; others are advanced concepts using low-enrichment U. All have stainless-steel-clad fuel and double-walled flow tube. Stagnant steam between walls acts as thermal barrier to water moderator. Spiral wire spacers maintain space between components

Sioux Falls Reactor Data

Plant	
Power, boiling region	164,000 kw
Power, superheating region	39,700 kw
Total core power	203,000 kw
Gross electrical capability	66,000 kw
Net electrical output	62,000 kw
Net efficiency	30.5%
Steam outlet pressure	540 psi
Reactor operating pressure	600 psi
Temperature, boiling region	489° F
Outlet temperature, superheating region	825° F
Gross heat rate	10,172 Btu/kwh
Containment shell size	50 ft × 120 ft
Reactor	
Vessel size	11½ × 27½ ft
Total core dimensions	6 × 6 ft
Dimensions of super-heater	6 × 1½ ft
Fuel, boiling region (Al clad)	~1.8% enriched UO_2
Fuel superheater (s.s. clad)	93% enriched UO_2
Fuel, loading, boiling region	117 kg (U^{235})
Fuel, loading, superheating region	34 kg (U^{235})
Power density, (boiling core coolant)	96 kw/liter
Average heat flux, boiling region	131,000 Btu/hr/ft²
Average heat flux, superheater	85,000 Btu/hr/ft²
Max heat flux, boiling region	432,000 Btu/hr/ft²
Max heat flux, superheater	238,000 Btu/hr/ft²
Recirculation rate	60,000 gpm
Recirculation pump power	794 kw
Superheater Section	
Max fuel surface temperature	1,330° F
Average film coefficient	350 Btu/hr/ft²
Pressure drop	55 psi
Inlet velocity	99 ft/sec
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The fact that the superheater depends on the boiling section for its coolant supply poses problems for startup and emergency scrams for any integral-superheat reactor. To prevent starving the super-heater for coolant during a scram, the Sioux Falls design calls for an automatic regulating valve between the reactor and condenser that would provide a gradually tapering steam supply to the superheater. When the pressure drops low enough, the superheater would be flooded with water.

In the startup situation the procedure would be to first let the reactor heat up at low power level [12 Mw(th)] with the superheater flooded and the four superheater control rods inserted. Then the reactor is shut down and, after a 5-min delay to let decay heat fall to an acceptable value, the superheater is drained. The reactor is again made critical and steam pressure gradually built up at low power with the superheater control rods still inserted. After about an hour the reactor reaches operating pressure and temperature and can then go up to full power.

Accidental flooding of the superheater section with water is the reverse of superheater starvation. One would expect the increase in moderation to give a positive jolt in reactivity. However Sioux Falls designers believe they can make this "flooding coefficient" either positive or negative by adjusting the superheater lattice parameters. For the reactor design their philosophy has been to minimize the flooding coefficient over core life. They predict a coefficient at start of life of 0.2% in k_{∞}; as the fuel burns out, this will fall to zero at middle of life and turn slightly negative near end of life. The 4% Δk_{∞} safety shutdown margin will easily over ride an accidental reactivity jolt of this size resulting from an accidental flooding—an event believed to be extremely improbable in the first place.

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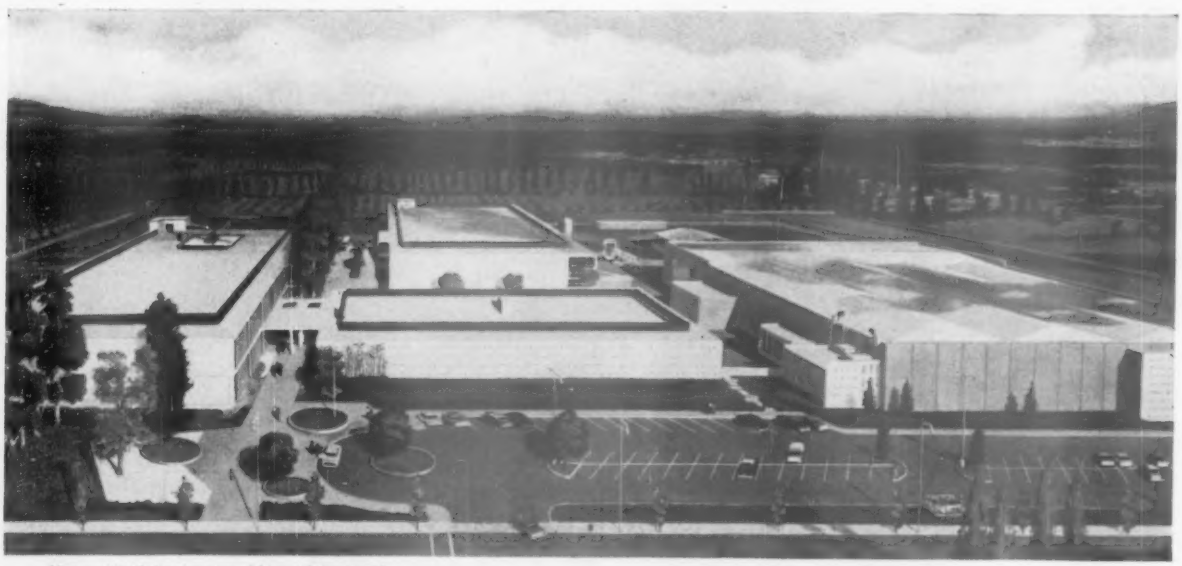

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Scanning the Literature

The Worth of Control Rods, A Theoretical Method for Determining. A general recipe for calculating rod worth when a diffusion theory description of the core without rods is available. Comparison with experiments indicates an accuracy equal to that of the no-rod calculation is obtained. (WAPD-218; $1.50*)

Electrical Heating Methods of Liquid-Metal Systems. A discussion and comparison of three heating methods (resistance, induction and transformer heating) for liquid-metal piping systems. (NAA-SR-3882; $0.50*)

Industrial-Process and Space Heat from Nuclear Reactors. A world-wide literature search dated October 1959 that lists 45 references in the field. (TID-3537; $0.50*)

Burnout of Heating Surfaces in Water. An empirical formula for burnout heat flux is fitted by a digital computer to the existing experimental data. (DP-363; March '59; $1.50*)

Nuclear Reactor Simulation By Analog Computer—A survey of the literature through 1958 that lists some 80 abstracts of references in the field. (NAA-SR-3708; Dec. '59; $1.75*)

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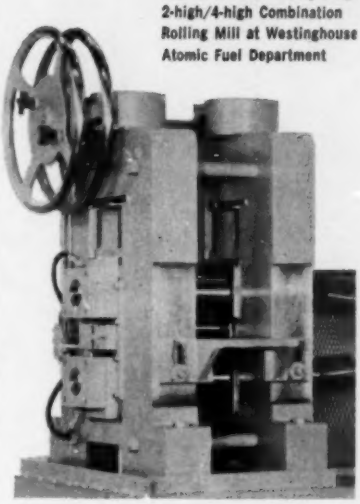

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Calculating Gamma Spectra from Reactors

By R. L. FRENCH, *Convair, Fort Worth, Texas*

We have developed a method for calculating the gamma spectrum and dose rate from an operating nuclear reactor which provides reliable results for shielding and heating calculations (*1*). The method makes direct use of "differential energy spectra" for point, isotropic, monoenergetic gamma sources in infinite media; this is in contrast to conventional methods that use buildup factors (usually derived from differential energy spectra) and hence sacrifice spectral definition. Our method, which preserves spectral definition, is made practical because differential energy spectra—such as those calculated by Goldstein and Wilkins (*2*)—are available for a wide range of materials or may be interpolated on the basis of atomic number or "effective atomic number" for any material.

Method

The basic equation used with the method is

$$S_n(E') = S_{n-1}(E')e^{-\mu r} + \int_{E'}^{E_{max}} \frac{S_{n-1}(E)f(T)}{e^{\mu' r} - E'}\, dE \quad (1)$$

Here $S_{n-1}(E)$ is the spectral intensity of a point isotropic source of gamma rays (photons/sec/Mev) and $S_n(E')$ is the modified intensity (photons/sec/Mev) at energy level E' after penetration of r cm of a given material. The quantities μ and μ' are the total linear attenuation coefficients of the material for photons of energies E and E', respectively, and $f(T)$ is the differential energy spectrum

$$f(T) = 4\pi r^2 e^{\mu r} I_0 \quad \frac{\text{Mev/sec/Mev}}{\text{source photon/sec}}$$

in which I_0 is defined as the energy per unit energy interval carried by photons of energy E' which in unit time cross a unit area whose normal is in the direction of motion divided by the number of source photons emitted per second with initial energy E.

In its simplest application, Eq. 1 gives the modified gamma spectrum $S_n(E)$ at distance r from a point isotropic gamma source $S_{n-1}(E)$ engulfed in an infinite medium. The total spectrum consists of two components: The first term of Eq. 1 is the uncollided flux, and the second term gives the scattered component. The equation may be used to describe the gamma spectra from a volume source such as a reactor if certain qualifying assumptions are permitted.

Assumptions

We assume that the reactor can be represented by an array of point sources, each corresponding to an elemental volume of the core. The contribution to the total gamma spectrum at a given position is calculated by considering the materials along the line of sight between each point source and the position of interest.

The contribution from a single source point usually involves the penetration of two or more layers of material: the core material between the source point and the core boundary, the reflector and/or any shield material between the core and the point of interest. We apply Eq. 1 to individual layers by treating the penetration as though the layers were infinite in extent. In the successive penetration of several layers, the source term for the nth layer is the emergent spectrum $S_{n-1}(E)$ from the preceding layer. This treatment tacitly assumes that at each boundary all the scattered photons are moving in a radial direction with respect to the original source point. This assumption has a reasonably sound basis in that gamma rays are scattered preferentially in the forward direction. Investigations* have shown that for typical reactor spectra the assumption should rarely lead to more than a 5% error in dose rate when crossing a given boundary.

The final result from each source point must be divided by $4\pi R^2$ to obtain spectra in flux units (photons/cm²/Mev), where R is the geometrical distance between the original source point and the point of interest. Dose rates may be obtained by applying the appropriate flux-to-dose conversion function and integrating over the spectrum.

Example

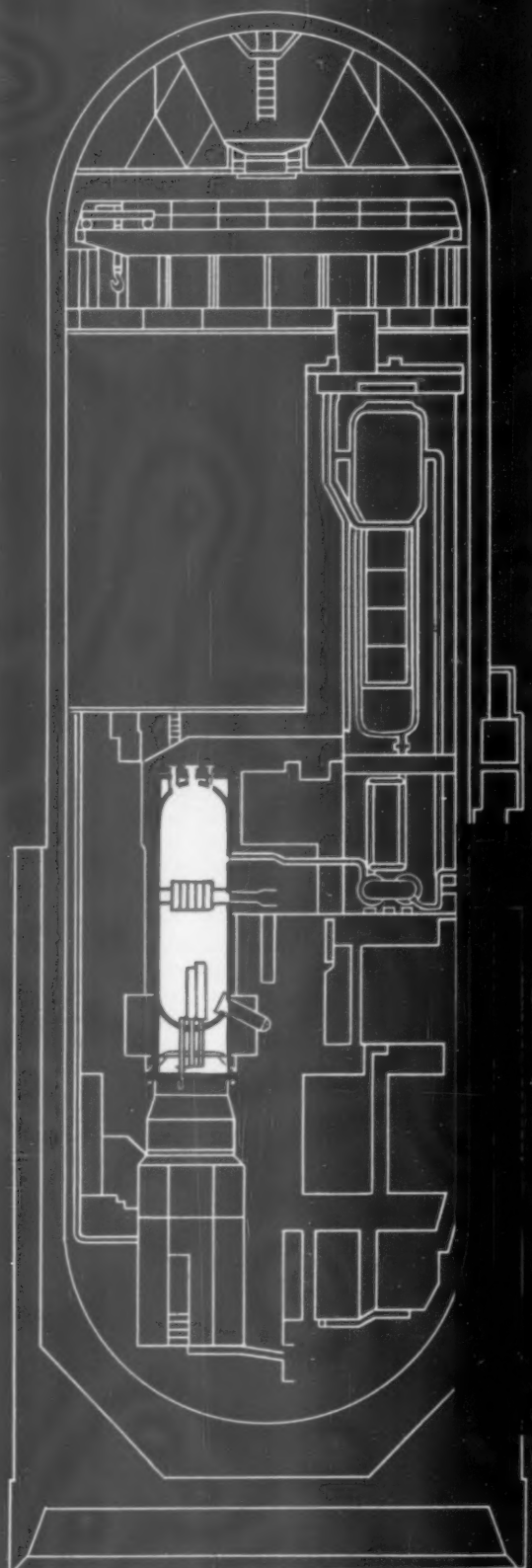
To illustrate the method, we present comparisons of measured and calculated data for the Convair Ground Test Reactor (GTR) and the Oak Ridge National Laboratory Bulk Shielding Reactor (BSR). Both reactors are made up of MTR-type fuel elements and are essentially identical. A rectangular array of 96 source points represented the reactor core for the penetration calculations. The source term $S_0(E)$ included the prompt gammas from U^{235} thermal fission, gammas from fission products and capture gammas from the aluminum, U and hydrogen in the reactor. The composite source spectrum is

Energy (Mev)	*Source strength (photons/fission/Mev)*
0	0
0.5	10.51
1.0	5.77
2.0	1.97
3.0	0.585
4.0	0.246
6.0	0.051
8.0	0.037
10.0	0

The aluminum, uranium and moderator water in each fuel element were assumed to be uniformly distributed over the volume of the fuel element. The measured thermal-flux profile through the GTR core established the relative strength of each source point. The total source strength of 3.11×10^{10} fissions/sec corresponds to a reactor power level of 1 watt.

Figure 1 shows the experimental arrangement and gives a comparison of calculated and measured dose rates from a lead-shadow-shield experiment (*3*) which was performed with Convair's GTR. Dose rates were measured as a function of lead thickness t with both the reactor and the shield submerged in water. Each of the

* The investigations were made by repeating single medium-penetration calculations, assuming division into various numbers of layers. On occasion, the method described here has been confused with the "straight-ahead approximation method" described by Goldstein (*6*), which neglects the angular deviation of photons caused by scattering collisions. It should be emphasized that the present method assumes that the photons are moving straight ahead (along a radius from the source point) only when crossing a boundary.



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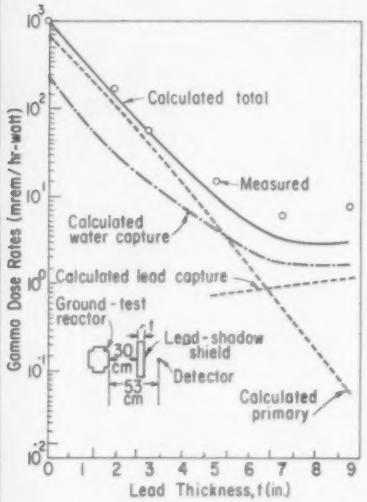

FIG. 1. GAMMA DOSE RATES from GTR in water behind shadow shield agree with total calculated by method of article

three dotted-line components shown in Fig. 1 was calculated by the method described here. The component labeled "water capture" is due to the $H^1(n,\gamma)H^2$ reaction in the water external to the GTR core. The dose rate from the water and lead capture gammas becomes more important than the primary gamma dose rates for lead thickness greater than 5 in.

Measured and calculated gamma dose rates in pure water along the centerline of the GTR and BSR are compared in Fig. 2. The part of the

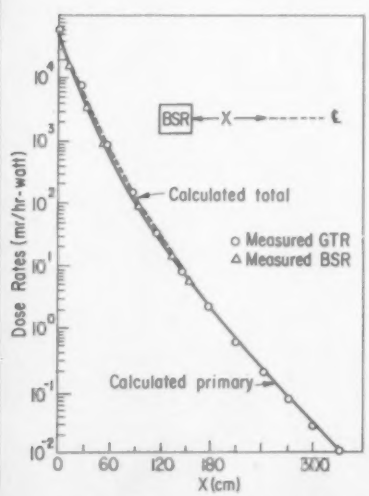

FIG. 2. DOSE RATES from gammas on BSR centerline agree with similar measurements in GTR and calculated values

dose rate from water capture is approximately 20% of the total dose rate in the range investigated (*4*). The calculated total dose rate and both sets of experimental dose rates agree within a few percent, although the calculations were performed explicitly for the GTR.

Maienschein and Love (*5*) have reported gamma spectral measurements along the centerline of the BSR. The measurements were made with a collimated spectrometer and, hence, are not directly comparable to the total spectra (as would be observed by a nondirectional spectrometer) calculated by the method described here. A normalization at 4 Mev, however, allows the comparison of the shape of measured and calculated spectra, shown in Fig. 3. The agreement between the measured and calculated spectra for the face of the BSR ($x = 0$) is good in the 0.5–8-Mev energy range. The best agreement would be expected for this position, since the scattered component is least close to the core. At separation distances of 147 cm and 267 cm, the marked discrepancy below 2 Mev is probably due to the extremely small solid angle of the collimator (the collimator shields the spectrometer crystal from gamma rays that have been scattered through large angles).

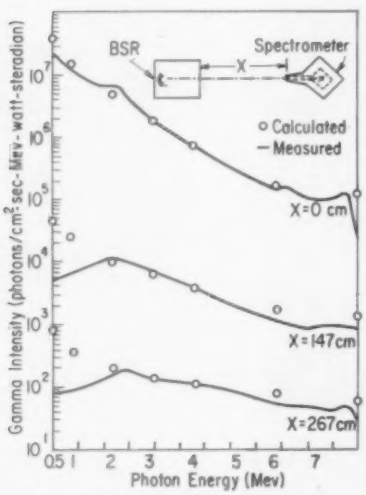

FIG. 3. GAMMA INTENSITY vs. photon energy along BSR centerline—spectrometer measurements agree with calculated values

Computations for the above examples were performed on an IBM-704 computer with a program that allows for various reactor geometries, shield arrangements and material compositions. Approximately 4 min of machine time was required to calculate the spectra and dose rate for a given position. Parametric studies have shown that the 96 source points are adequate. In the examples considered, the primary dose rates were calculated to within 10–20%. Extensive applications to other problems have yielded equally favorable results.

BIBLIOGRAPHY

1. R. L. French. Reactor shield penetrations, Convair–Fort Worth Report FZM-913 (May, 1957)
2. H. Goldstein, J. E. Wilkins, Jr. Calculations of the penetrations of gamma rays, Nuclear Development Associates Report NDA-15C-41 (June 30, 1954)
3. R. L. Kloster. Analysis of lead shadow shield experiment, Convair–Fort Worth Report FZK-9-113 (April, 1957)
4. C. E. Humphries, B. J. Workman. A comparison between BSR centerline dose rates and dose rates calculated by the moments method, Convair–Fort Worth Report MR-N-84 (March, 1956)
5. F. Maienschein, T. Love. Gamma-ray spectrum of the bulk shielding reactor, NUCLEONICS **12**, No. 5, 6 (1954)
6. H. Goldstein. The attenuation of gamma rays and neutrons in reactor shields, p. 141 (Government Printing Office, Washington, D. C., May, 1957)

Fast-Neutron and Gamma Spectra for BSR

By R. L. FRENCH and J. B. EGGEN, *Convair, Fort Worth, Texas*

Gamma and fast-neutron dose rates and thermal-neutron fluxes on the centerline of the Bulk Shielding Reactor (*1, 2*) (at Oak Ridge National Laboratory) have proved useful for "back-of-the-envelope" shielding calculations. These data have been accompanied to date by relatively little data on the gamma and fast-neutron spectra (*2, 3*). Tables 1 and 2 present complete calculated gamma and fast-neutron spectra—information that

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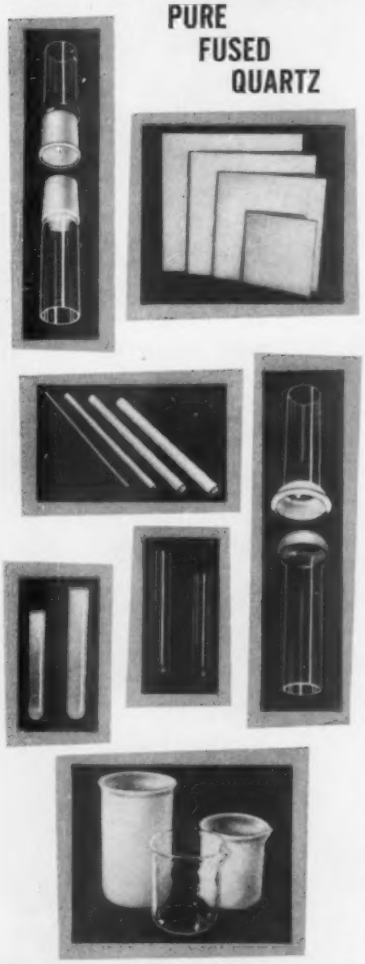

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TABLE 1—BSR Gamma Spectra and Dose Rates in Water

Distance from BSR (cm)	Gamma energy (Mev) 0.5	1.0	2.0	3.0	4.0	6.0	8.0	Dose rate (mrem/hr/watt)
	Spectral intensity (photons/cm²/sec/Mev/watt)							
0	$2.73 \cdot 10^{7}$	$1.04 \cdot 10^{7}$	$3.47 \cdot 10^{6}$	$1.17 \cdot 10^{6}$	$5.17 \cdot 10^{5}$	$1.2 \cdot 10^{5}$	$8.63 \cdot 10^{4}$	$5.02 \cdot 10^{4}$
10	$1.28 \cdot 10^{7}$	$3.92 \cdot 10^{6}$	$1.25 \cdot 10^{6}$	$4.42 \cdot 10^{5}$	$2.01 \cdot 10^{5}$	$4.86 \cdot 10^{4}$	$3.52 \cdot 10^{4}$	$2.00 \cdot 10^{4}$
20	$5.11 \cdot 10^{6}$	$1.60 \cdot 10^{6}$	$5.12 \cdot 10^{5}$	$1.90 \cdot 10^{5}$	$8.85 \cdot 10^{4}$	$2.25 \cdot 10^{4}$	$1.64 \cdot 10^{4}$	$8.25 \cdot 10^{3}$
40	$9.70 \cdot 10^{5}$	$3.34 \cdot 10^{5}$	$1.14 \cdot 10^{5}$	$4.64 \cdot 10^{4}$	$2.28 \cdot 10^{4}$	$6.40 \cdot 10^{3}$	$4.68 \cdot 10^{3}$	$1.80 \cdot 10^{3}$
60	$2.27 \cdot 10^{5}$	$8.53 \cdot 10^{4}$	$3.13 \cdot 10^{4}$	$1.40 \cdot 10^{4}$	$7.27 \cdot 10^{3}$	$2.25 \cdot 10^{3}$	$1.65 \cdot 10^{3}$	$4.91 \cdot 10^{2}$
80	$6.29 \cdot 10^{4}$	$2.51 \cdot 10^{4}$	$9.87 \cdot 10^{3}$	$4.81 \cdot 10^{3}$	$2.63 \cdot 10^{3}$	$8.96 \cdot 10^{2}$	$6.60 \cdot 10^{2}$	$1.56 \cdot 10^{2}$
100	$1.96 \cdot 10^{4}$	$8.21 \cdot 10^{3}$	$3.42 \cdot 10^{3}$	$1.80 \cdot 10^{3}$	$1.03 \cdot 10^{3}$	$3.87 \cdot 10^{2}$	$2.86 \cdot 10^{2}$	$5.56 \cdot 10^{1}$
120	$6.71 \cdot 10^{3}$	$2.91 \cdot 10^{3}$	$1.27 \cdot 10^{3}$	$7.14 \cdot 10^{2}$	$4.32 \cdot 10^{2}$	$1.76 \cdot 10^{2}$	$1.31 \cdot 10^{2}$	$2.14 \cdot 10^{1}$
150	$1.54 \cdot 10^{3}$	$6.89 \cdot 10^{2}$	$3.20 \cdot 10^{2}$	$1.95 \cdot 10^{2}$	$1.27 \cdot 10^{2}$	$5.84 \cdot 10^{1}$	$4.36 \cdot 10^{1}$	$5.77 \cdot 10^{0}$
180	$3.99 \cdot 10^{2}$	$1.82 \cdot 10^{2}$	$8.92 \cdot 10^{1}$	$5.80 \cdot 10^{1}$	$3.99 \cdot 10^{1}$	$2.06 \cdot 10^{1}$	$1.54 \cdot 10^{1}$	$1.73 \cdot 10^{0}$
210	$1.15 \cdot 10^{2}$	$5.27 \cdot 10^{1}$	$2.69 \cdot 10^{1}$	$1.84 \cdot 10^{1}$	$1.33 \cdot 10^{1}$	$7.62 \cdot 10^{0}$	$5.73 \cdot 10^{0}$	$5.59 \cdot 10^{-1}$
250	$2.47 \cdot 10^{1}$	$1.14 \cdot 10^{1}$	$6.04 \cdot 10^{0}$	$4.32 \cdot 10^{0}$	$3.31 \cdot 10^{0}$	$2.13 \cdot 10^{0}$	$1.61 \cdot 10^{0}$	$1.37 \cdot 10^{-1}$
300	$4.23 \cdot 10^{0}$	$1.94 \cdot 10^{0}$	$1.06 \cdot 10^{0}$	$7.87 \cdot 10^{-1}$	$6.32 \cdot 10^{-1}$	$4.59 \cdot 10^{-1}$	$3.47 \cdot 10^{-1}$	$2.63 \cdot 10^{-2}$
350	$8.14 \cdot 10^{-1}$	$3.72 \cdot 10^{-1}$	$2.05 \cdot 10^{-1}$	$1.57 \cdot 10^{-1}$	$1.30 \cdot 10^{-1}$	$1.04 \cdot 10^{-1}$	$7.87 \cdot 10^{-2}$	$5.50 \cdot 10^{-3}$

should increase the usefulness of BSR centerline data. We have demonstrated the validity of the calculated data by comparison with measured data.

The method described in the previous article by French (*4*) was used to perform the gamma calculations. Gamma rays from prompt fission, from decay of fission products (assuming equilibrium) and from hydrogen, aluminum and uranium capture in the BSR core were considered in the calculations. The BSR core was represented by an array of 132 source points, the relative strength of each source point being determined from measured power distribution data for loading No. 33 of the BSR.

For the fast-neutron calculations we assumed that the core material and water that is penetrated along the line of sight between a source point inside the core and a position on the centerline could be represented by an equivalent thickness of pure water,

$$t_{eq} = t_c \frac{\Sigma_c}{\Sigma_w} + t_w$$

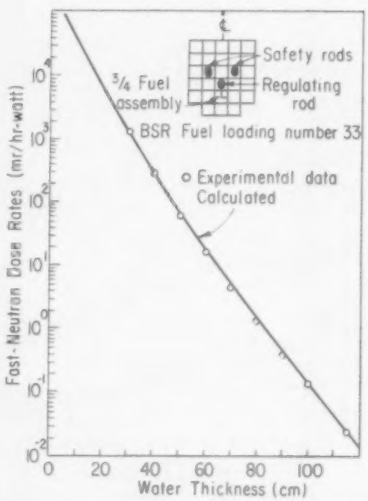

FIG. 1. FAST-NEUTRON DOSE RATES measured on BSR centerline in water

where t_c and t_w are the actual thicknesses through core material and water, respectively, and Σ_c/Σ_w is the ratio of the macroscopic removal cross section of the composite core material and the water.

TABLE 2—BSR Fast-Neutron Spectra and Dose Rates in Water

Distance from BSR (cm)	Neutron energy (Mev) 0.33	1.1	2.7	6.0	10.9	Dose rate (mrem/hr/watt)
	Spectral intensity (neutrons/cm²/sec/Mev/watt)					
0	$1.66 \cdot 10^{6}$	$7.47 \cdot 10^{5}$	$4.19 \cdot 10^{5}$	$5.63 \cdot 10^{4}$	$1.57 \cdot 10^{2}$	$2.34 \cdot 10^{4}$
10	$1.79 \cdot 10^{5}$	$8.95 \cdot 10^{4}$	$5.58 \cdot 10^{4}$	$1.03 \cdot 10^{4}$	$3.28 \cdot 10^{2}$	$3.29 \cdot 10^{4}$
20	$2.42 \cdot 10^{4}$	$1.36 \cdot 10^{4}$	$9.0 \cdot 10^{3}$	$2.30 \cdot 10^{3}$	$8.31 \cdot 10^{1}$	$5.84 \cdot 10^{3}$
40	$7.58 \cdot 10^{2}$	$4.98 \cdot 10^{2}$	$3.45 \cdot 10^{2}$	$1.55 \cdot 10^{2}$	$7.20 \cdot 10^{0}$	$2.79 \cdot 10^{2}$
60	$4.31 \cdot 10^{1}$	$2.72 \cdot 10^{1}$	$1.96 \cdot 10^{1}$	$1.27 \cdot 10^{1}$	$7.61 \cdot 10^{-1}$	$1.85 \cdot 10^{1}$
80	$3.78 \cdot 10^{0}$	$2.04 \cdot 10^{0}$	$1.54 \cdot 10^{0}$	$1.17 \cdot 10^{0}$	$8.98 \cdot 10^{-2}$	$1.51 \cdot 10^{0}$
100	$3.82 \cdot 10^{-1}$	$2.01 \cdot 10^{-1}$	$1.50 \cdot 10^{-1}$	$1.15 \cdot 10^{-1}$	$1.14 \cdot 10^{-2}$	$1.44 \cdot 10^{-1}$
120	$2.97 \cdot 10^{-2}$	$2.55 \cdot 10^{-2}$	$1.45 \cdot 10^{-2}$	$1.19 \cdot 10^{-2}$	$1.51 \cdot 10^{-3}$	$1.52 \cdot 10^{-2}$

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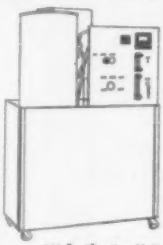

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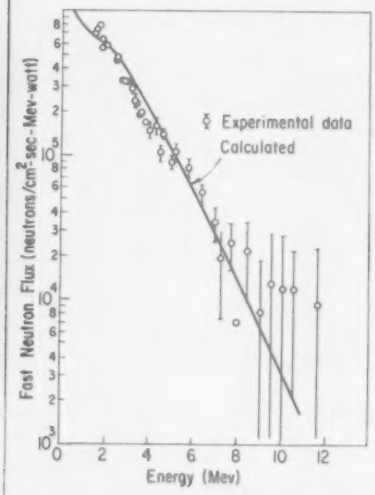

FIG. 2. FAST-NEUTRON LEAKAGE spectrum calculated and observed for BSR

The dose rate and spectra for each source point were then determined directly from moments-method data (*5*) for point isotropic sources of fission neutrons in water. A summation of the dose rate and spectra from individual source points gave the total dose rates and spectra at the positions indicated in Table 2. Figure 1 shows a comparison of the calculated and measured fast-neutron dose rates. The agreement is within 10% over the entire range. Agreement of the calculated and measured leakage spectra (*1, 2*) for the BSR is essentially within the experimental error (Fig. 2), even though the measurements were made with a collimated proton-recoil counter (which looks in only one direction) and the calculations were performed for a point 4π detector.

The gamma and fast-neutron spectra are especially useful in determining the penetration through or heating of materials placed in water near a BSR-type reactor. For gamma rays in particular, the use of the continuous energy spectrum rather than of an average or "effective" gamma-ray energy gives results of considerably greater accuracy.

BIBLIOGRAPHY

1. T. V. Blosser, ORNL-2081 (1956); "Research Reactors," ch. 2, USAEC (Government Printing Office, Washington, D. C., 1955)
2. H. Goldstein. The attenuation of gamma rays and neutrons in reactor shields (Government Printing Office, Washington, D. C., 1957)
3. F. Maienschein, T. Love, NUCLEONICS **13**, No. 5, 6 (1954)
4. R. L. French. Calculating gamma spectra from reactors, NUCLEONICS, this issue, p. 114
5. R. Aronson, J. Certaine, H. Goldstein, S. Preiser, NYO-6267 (1954)

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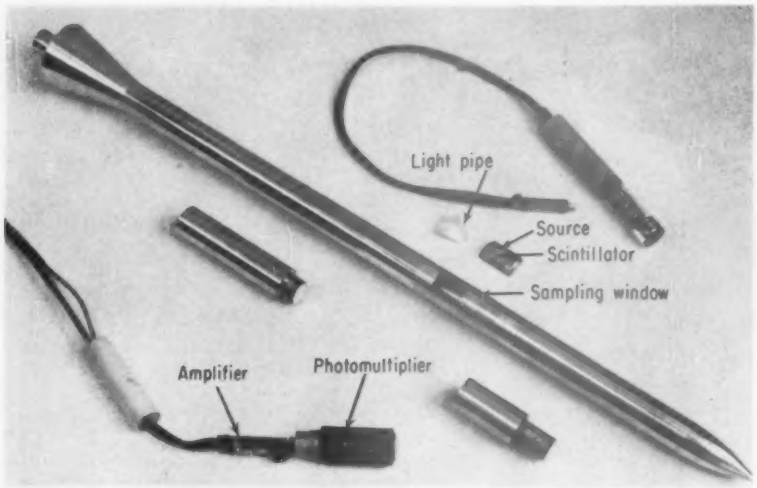

DENSITY ALTIMETER USES BETA BACKSCATTER from low energy source to measure density of surrounding air. Detector is stilbene scintillator

Beta Backscatter Measures Altitude

When you fly low enough and slow enough, you can measure altitude in the old-fashioned way: use a static tube and observe atmospheric pressure. But as planes and rockets go faster, it becomes harder and harder to design a static tube that will give you the true static pressure in the air through which you are traveling. As you go higher, the quantity you measure gets smaller, and the altitude error becomes greater. New methods are required.

You can meet the second difficulty, measuring smaller static pressures, with a density gage consisting of an alpha-particle source and an ionization chamber. This still leaves the sampling problem—getting an atmosphere inside that accurately represents the atmosphere outside.

Two Boeing engineers, Donald Wright and Donald Blincow, meet both problems with a density altimeter that uses beta backscatter. Its cost is less than half that of the only density altimeter now available. With a 4-mc Pm^{147} source it offers a counting-rate change from 161,220 cpm at 10,000 ft to 17,000 cpm at 66,000 ft.

Beta particles from low-energy emitters like C^{14} (0.158 Mev, 30-year half-life) and Pm^{147} (0.23 Mev, 2.6-year half-life) are directed into the atmosphere from a window at the side of a probe (see photograph). Radiation scattered by the surrounding air comes back to a stilbene scintillator connected by light pipes to two photomultipliers. Operating the photomultipliers in coincidence reduces background. The makers are also considering an ionization-chamber detector. The photograph shows the parts of the system that go into a 30-in. streamlined melamine tube to make an atmospheric-density probe.

Error in the static-density measurement is constant with altitude. Thus in contrast with static-pressure instruments, the new density altimeter has an absolute error that decreases with increasing altitude. Boeing will conduct a flight-test program to determine absolute errors in actual flight. The Flight Controls Section of Wright Air Development Center may support future testing.

The plan is to use each altimeter where it is most effective: a pressure altimeter up to ~25,000 ft and a backscatter altimeter above that. Above 25,000 ft atmospheric density is relatively constant in time. Below 15,000 ft the pressure altimeter is the better of the two. Between these two levels both systems are satisfactory. The upper altitude limit for the backscatter method will be where cosmic rays and electronics offer objectionable noise in comparison with the backscatter counting rate.

Toad Tracers Study Hibernation Habits

Did you think that toads did their hibernating in the mud of ponds and streams? No. It appears that they go to higher ground and burrow into it. This is one of the discoveries of Walter Breckenridge, University of Minnesota, who is marking his toads with tantalum-182 and following them with scintillation detectors. The purpose is to find out what they do in the wintertime. Where do they hibernate? How deep? How many freeze to death?

Breckenridge and his assistants caught about 20 toads during late summer. Under the skin of the backs were inserted 5-mm bits of tantalum wire irradiated at Oak Ridge to produce ~100 μc of 112-day Ta^{182}. As far as can be determined from several weeks of observation, the wire did no harm to the toads.

The experimenters released the toads and traced their daily programs using a scintillation survey meter. The toads seldom move more than 100 ft during a night, and the meter, with a range of ~20 ft, easily picked them up the next day.

In the middle of October the toads went underground for winter hibernation. Contrary to general belief, they moved up to surrounding prairies, not down to marshes and ponds.

The researchers are still following them, even now that they are underground. With a soil-sampling auger they drill two 3-in. holes, each about 1 ft from the buried toad. Down one hole goes a staff with thermocouples every 4 in. Soil is packed around the staff, and the thermocouples permit the scientists to record ground temperatures through the winter. The other hole is covered but left empty. A scintillation probe can be put down into it to find the depth of the toad and see whether he goes deeper as the weather gets colder.

As weather and ground temperature become colder, Breckenridge and his students will take repeated readings. They hope to find out whether extreme cold wakes the toads enough to make them burrow deeper into the ground and avoid freezing to death. Next spring when the toads wake and come up for light, they will know when each one emerges and how many survive the winter.

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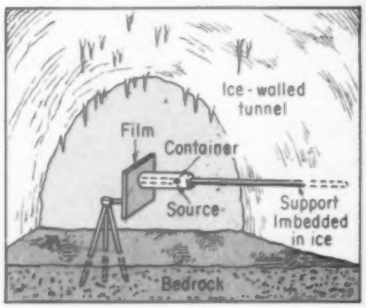

Sr^{90} Pen Traces Ice-Cap Movement

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As shown in the sketch, the film is vertical. A small Sr^{90} source (<50 μc) emits its rays through a narrow collimating channel in its container. Periodically a clock mechanism pushes the source closer to the film to leave a time marker on the trace. Installations at two sites will record vertical and horizontal movement of the ice cap for a full year.

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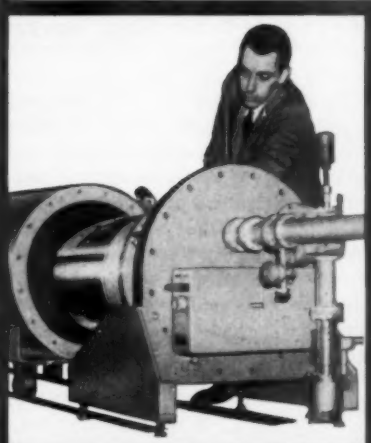

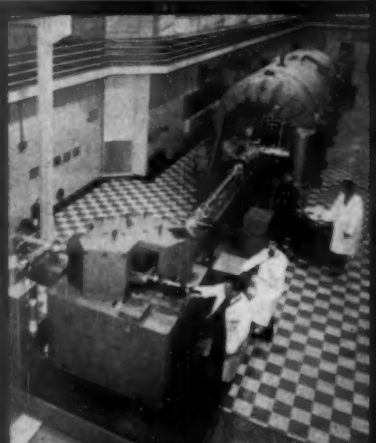

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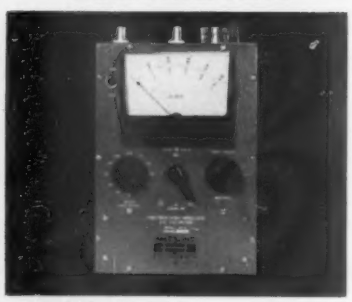

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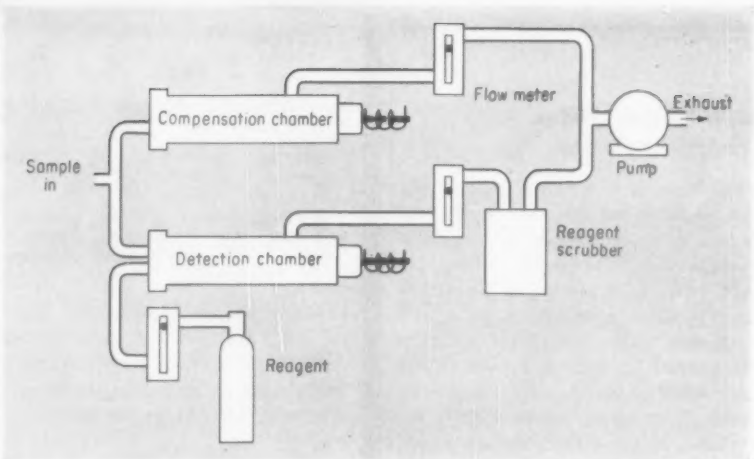

BALANCED CHAMBERS respond when contaminant reacts with reagent to form smoke in one but not to atmospheric changes that affect both

Balanced Ionization Chambers Offer Sensitive Gas Analysis

By L. E. MALEY, *Mine Safety Appliances Co., Pittsburgh, Pennsylvania*

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Making Smoke

Particles must be of appropriate size to produce maximum change in the steady-state chamber current for a given concentration of gaseous impurities. Smokes with particle diameters between 20 and 100 millimicrons present large surface areas and greatly increase recombination. Thus, if under controlled conditions 1 ppm of hydrogen fluoride reacts with ammonia to produce ammonium fluoride particles 0.1 micron in dia, the resulting smoke presents a total surface area of 10^{-3} cm² in our chamber. This smoke produces a 50% decrease in a steady-state current of 10^{-8} amp. Therefore if the gas of interest is treated with a suitable reagent, the resultant ion-current decrease is sensitive and specific for families of gases and vapors.

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Pyrolysis. Tetraethyl lead and nickel carbonyl form particles of lead and nickel, respectively, in response to high temperatures.

Hot solid reagents. A copper-oxide bed reacts with chlorinated hydrocarbons to form copper chloride particles.

Gases. To detect hydrogen chloride we add ammonia to form ammonium chloride particles.

Aqueous solutions. Air can be bubbled through acetic acid and the vapor reacted with amines to form acetate particles.

We use a cylindrical ionization chamber ~10 cm long and 2 cm in diameter. With these chambers the best flow rates for sample and reagent depend mainly on noise level; sensitivity increases with sample flow rate between 2 and 10 liters/min without appreciable increase in noise. The reagent flow is made great enough to

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If you are doing blood-brain barrier studies in order to investigate how different drugs get into the brain, you will probably be using many rats, guinea pigs, or monkeys. Each of these test animals will ultimately have to be sacrificed for brain dissection. Then, if you have used Carbon^{14} or Phosphorus^{32} to tag the drugs, each brain section (cortex, cerebellum, etc.) will have to be counted. In such cases the use of an automatic sample changer not only saves many hours of a technician's time but also improves the accuracy of the measurement by furnishing printed data.

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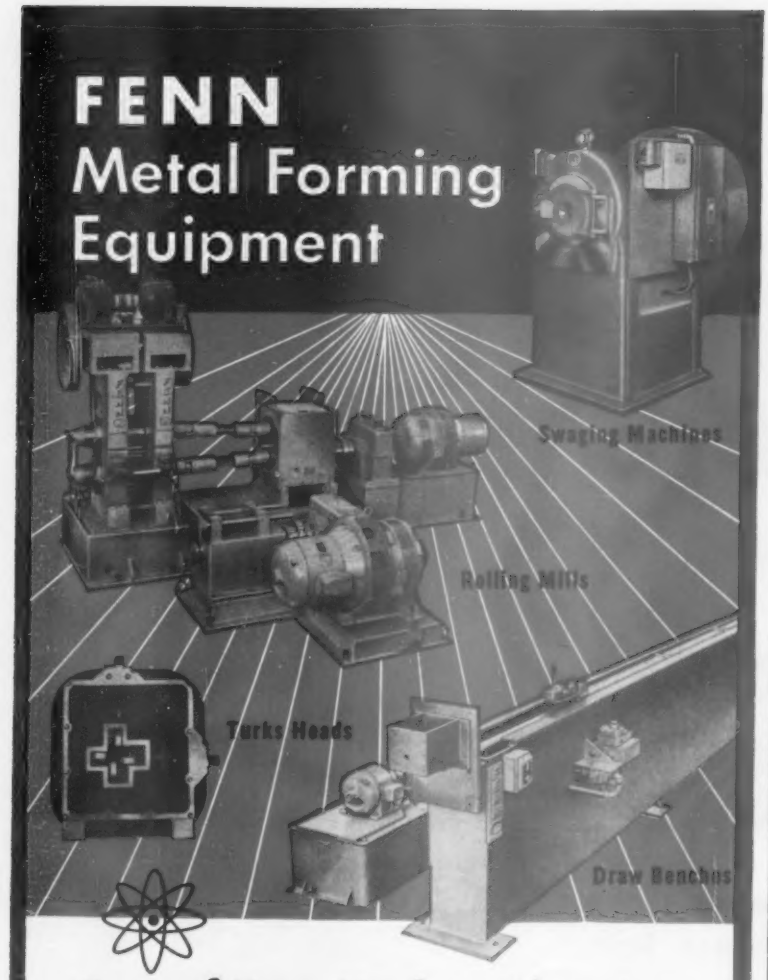

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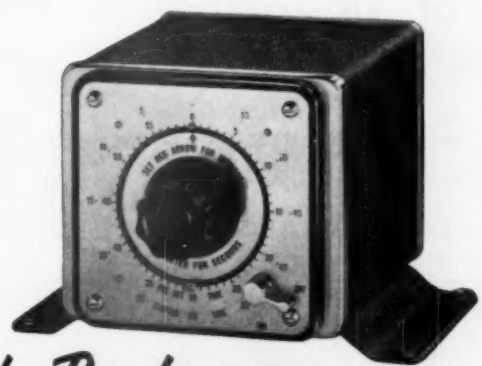

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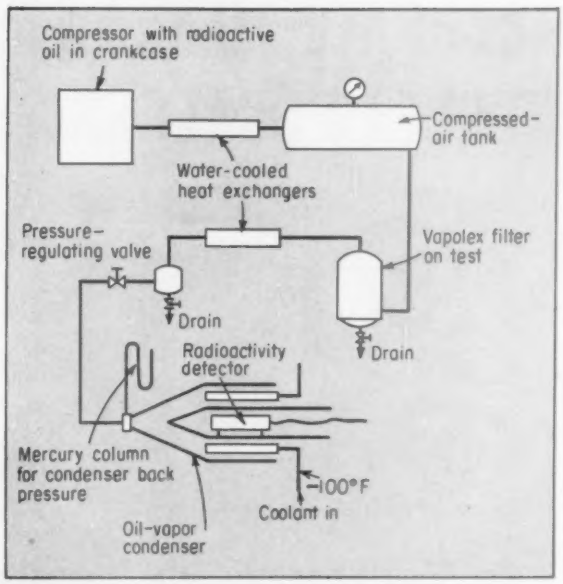

FIG. 1. TEST APPARATUS simulated filter performance in locomotive and traced smokelike oil with Sb^{124}

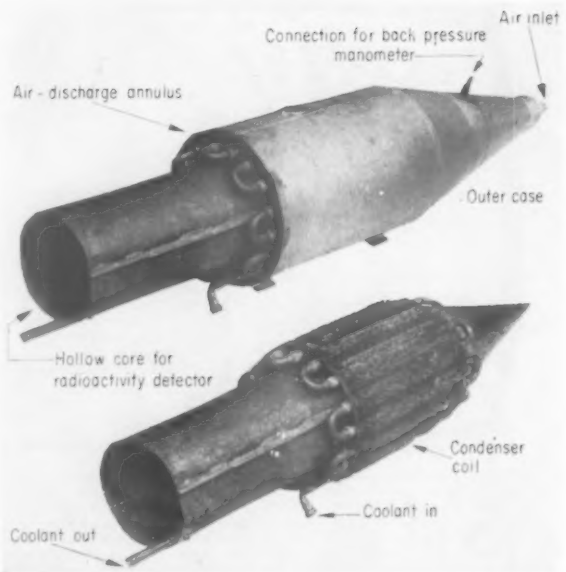

FIG. 2. VAPOR CONDENSER collected oil particles as discharge air passed over coils in 2-in. annulus

Tracers Test Efficiency of Air-Compressor Filters

By RALPH L. ELY, Jr.,* *Nuclear Science and Engineering Corp., Pittsburgh, Pennsylvania*
and JEROME R. PIER, *Westinghouse Air Brake Co., Pittsburgh, Pennsylvania*

Wherever there are oil-lubricated air compressors, some oil carry-over in compressor discharge lines must be accepted. When temperatures and speeds are low, oil particles are large (10 microns in diameter or larger) and can be easily collected by mechanical filters. The direct-connected air compressor on a diesel locomotive, however, runs at high speeds and high temperatures producing oil-carry-over particles so fine (<1 micron in diameter) that they look like smoke. Not only are these particles extremely hard to remove or collect; they tend to form varnishlike deposits in critical parts of air-brake equipment, impairing operation and making frequent cleaning necessary.

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In all this test work, engineers have difficulty evaluating a filter when the particles it is designed to remove are too small for detection by ordinary physical means. This makes efficiency testing long and its results questionable. To overcome this problem in the final testing of the Vapolex Filter, Westinghouse consulted Nuclear Science and Engineering Corp. about a radiotracer technique to track the oil particles. A procedure was worked out by engineers and scientists from both organizations whereby a radioactive tracer is added to the lubricating oil.

The tracer is Sb^{124} (60 days, 0.6-Mev gammas) in triphenylstibine. Two millicuries was added to 30 quarts of compressor oil in a container before filling the crankcase of the compressor. Thus the specific activity of the crankcase oil was 0.16 $\mu c/ml$. Only 15 quarts of oil was required for the original crankcase filling; the remainder was available as make-up oil during the test. The compressor, which delivers 165 standard ft^3/min, was operated in a system simulating a locomotive installation, including the filter to be tested. Figure 1 is a schematic diagram.

Testing

Air pressure in the system was maintained at 140 psi, and temperature was controlled with water-cooled heat exchangers to simulate locomotive service. The air was then expanded through the pressure-regulating valve

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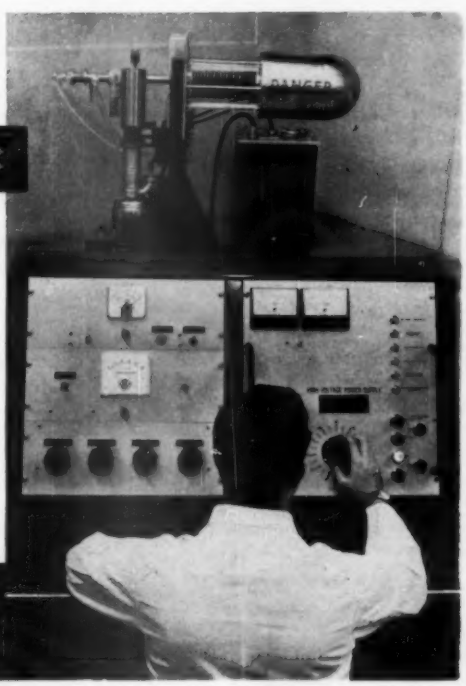

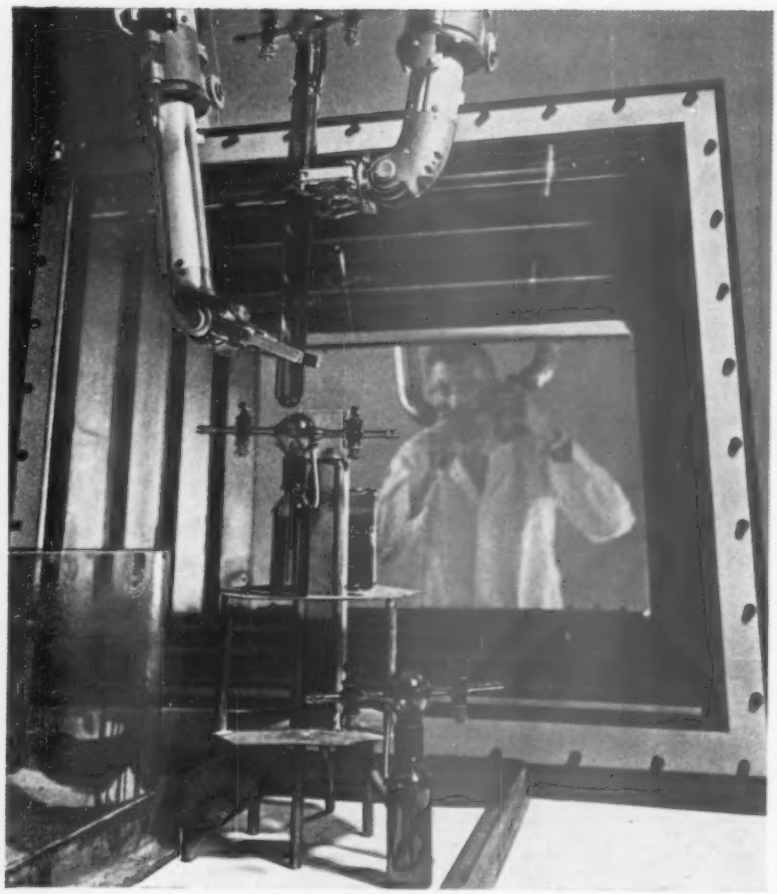

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This article starts on page 130

into an oil-vapor condenser (Fig. 2) in the form of a 10-in.-average-diameter annulus with an air-flow space of 2 in. This space was filled with a continuous run of heat-exchanger tubing (Thermek) through which passed a dry-ice–alcohol mixture at ~6 gpm and −100° F. Air passing through the condenser at 400 ft/min was cooled to −60° F, causing oil-vapor particles to condense and deposit on the heat-exchanger tubing.

A Nuclear-Chicago detector, with a 2- × 2-in. sodium iodide crystal with preamplifier, was at the center of the annulus. It read the activity of the condenser coil representing oil vapor collected, and transmitted this information to a Streeter-Amet scaler set to print out digitally every 5 min. Background counting rates were ~4,000 cpm with net sample-counting rates of 1,000–1,500 cpm.

Tracer Fractionation

Specific activity of the oil collected in the condenser-detector was about half the specific activity of the oil placed in the crankcase. A preliminary experiment had shown that the tracer and oil fractionated when the oil passed through a column containing the filter material. Fractionation in the filter element was not constant but varied with operating conditions. Thus, to determine accurately the amount of oil collected in the condenser-detector from the counting rate observed by the detector, we had to collect a sample of the oil in the condenser and determine the specific activity of this oil. From these measurements, it was determined that the sensitivity of the method was 50–150 cpm/ml of oil. Thus over-all counting efficiency for the detector in this geometry was ~0.5%. Variation of specific activity of the oil in the condenser-detector during a run was not a problem since specific activity was measured every 5–6 hr during the 200-hr run.

After the test, analysis of the filter elements for radioactivity showed the variations in oil concentration in different parts of the filter.

Safety

To ensure that the vapor condenser was removing all the oil particles from the air stream, we made frequent atmospheric-contamination checks using an air sampler with a Millipore filter at the discharge of the condenser. At

no time did these checks reveal radioactivity in the final discharge air.

Activity level was such that no complicated shielding was required. Westinghouse Air Brake Co. engineering test personnel operated the compressor, and Nuclear Science and Engineering Corp. personnel handled the radioactivity. Decontamination after the tests was accomplished by a simple washing operation. Because of the short half-life of the tracer, parts that cannot be washed satisfactorily will be safe after about a year's dead storage.

With the radiotracer technique we got information in a relatively short time that had previously been obtainable only from prolonged tests or not at all. Cost of the radioactive test for 300 hr of test time was approximately $6,500. Future tests of this type can probably be done with even less expenditure of time and money thanks to experience gained in this evaluation.

Other Oil Tracers

Several other oil-soluble tracers can be used for this experiment, among them iodine in an oil-soluble compound. It would be advantageous to investigate other possible tracers to eliminate the fractionation that occurs between the triphenylstibine and oil under these operating conditions. If a suitable tracer can be obtained, the calibration for specific activity at the end of each 6-hr run would be unnecessary.

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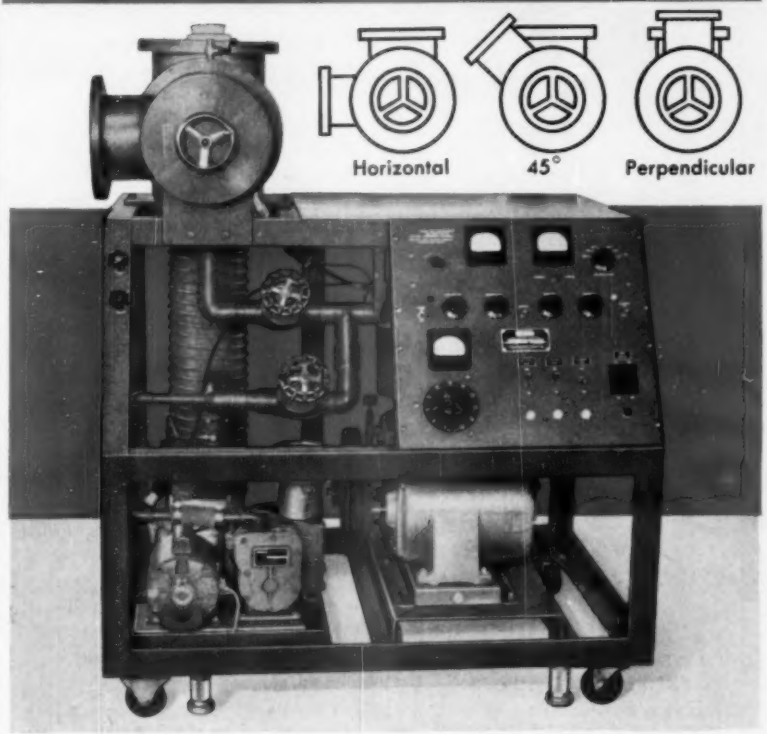

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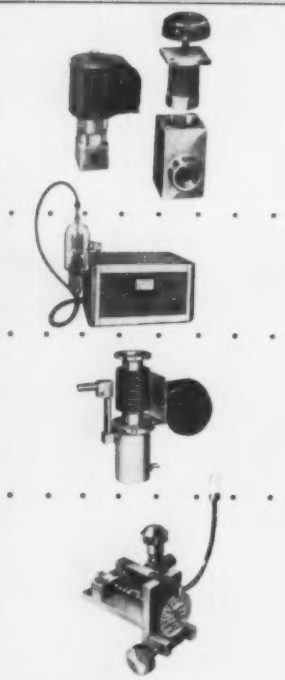

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Bright Spots on the Radiation Horizon

By S. EDWARD EATON
Arthur D. Little, Inc., Cambridge, Massachusetts

At the Warsaw conference, people looking along the road to commercial irradiation saw some bright spots on the horizon. Serious workers seemed to agree, perhaps for the first time, (a) that known features of radiation effects would soon produce new industrial processes (for example, crosslinking and graft copolymerization of plastics and sterilization of heat-sensitive products) and (b) that large-scale use of radiation, especially for chemical synthesis, requires some waiting and will be brought closer by better understanding of basic phenomena and important variables.

Among the 65 papers, 17 dealt with polymers, 12 with chemicals and petroleum, 3 with fission-fragment use for chemical synthesis, 2 with irradiated catalysts, 4 with foods, medical supplies and virus inactivation in vaccines, 15 with sources and 4 with costs. Work continues on some potential uses that have received little publicity: maturing of tomatoes, aging of wine, production of a smoked flavor in cheese and synthesis of static-free plastics. Reports of newly installed radiation sources indicate that effort in the field of irradiation technology is increasing.

Ion-Molecule Reactions

Radiolysis produces many reactive species: for example, carbonium ions, carbon anions, and triplet states. Perhaps the greatest hope from studying these species right now is the growing belief in the importance of ion molecules—molecules that have lost electrons by ionization. Ion molecules are, like free radicals, reaction-promoting intermediates, that is, excited species. But the reactions they induce are distinct; they can lead to unique products.

It appears that ionic reactions (ion-molecule reactions are an example) not only may be theoretically possible in gases at normal or high pressures but may in fact take place in some radiolytic liquid systems. Polymerization of isobutene at −80° C in the presence of zinc oxide powder shows negative temperature dependence and linear dose-rate dependence; both facts indicate an ionic polymerization (*1*, *2*). Polymerization of styrene and copolymerization of methyl methacrylate with styrene in methylenedichloride solutions at −80° C are also believed to be ionic for the same reasons (*2*).

High-pressure radiation-induced polymerization of ethylene (reported by Burton in 1954) and certain reactions in liquids may be ion-molecule reactions (*3*). One approach has been suggested for enhancing ion-molecule reactions in liquids: capture the electron produced in the initial radiolytic ionization with an additive that dissociates on capturing the electron (*3*).

Ions and ion molecules may compete with free radicals as the most useful intermediates for achieving useful radiation effects. If ion-molecule reactions can be made to proceed by a chain mechanism and thus produce large yields, a whole new field may be opened for radiation chemistry.

Research on Mechanisms

Basic studies of various modes of excitation transfer are multiplying For example, investigations of luminescent systems are beginning to shed light on relationships between *G*-values for radical formation, fluorescence intensity, and quenching agents (*2*). Fluorescence intensity of *p*-terphenyl in benzene irradiated with Co^{60} gammas has been studied with such quenching agents as carbon tetrachloride, monomers with conjugated and unconjugated double bonds, saturated compounds and several polymers. Ways of attaining higher *G*-values should result from such studies (*2*).

(*Continued on page 136*)

In an article last month the author discussed the efforts of radiochemists to invent practical irradiation processes. Here he turns attention to the most hopeful signs that such processes will be found.

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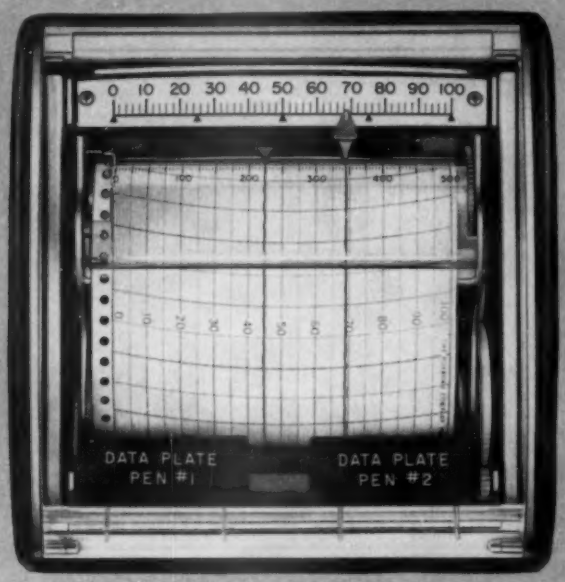

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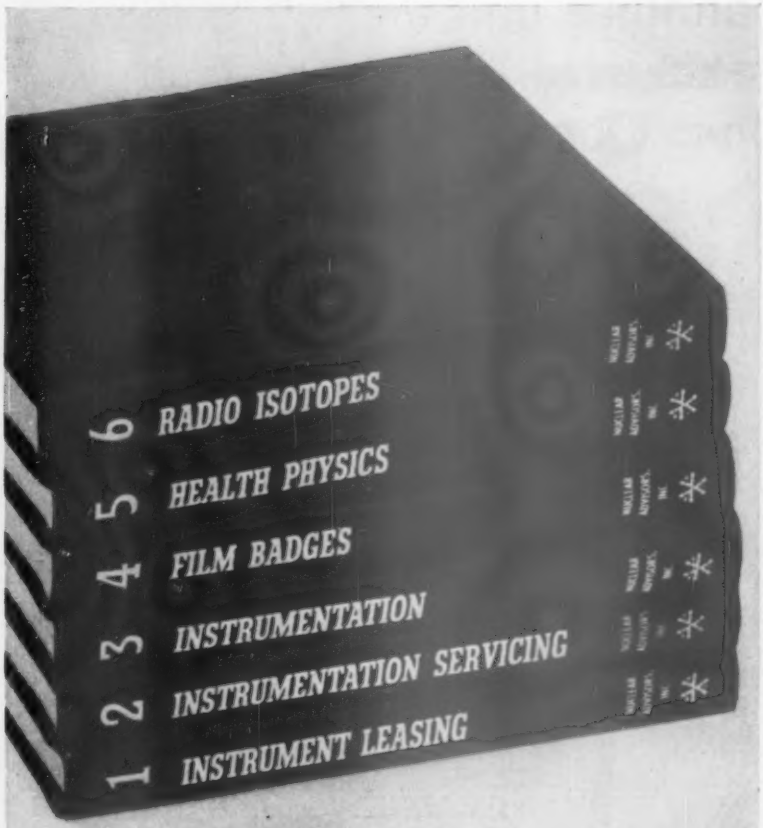

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APPLIED RADIATION

This article starts on page 134

Our understanding of radiation damage in solids and radiolytic activation of catalysts is increasing with examination of changes in luminescent properties of solid phosphors—for example, zinc sulfide irradiated with neutrons (*4*). Such studies should provide a theoretical basis for more applied research.

Cheaper Radiation

The need for low-cost radiation is shown not only by reported efforts of researchers seeking to increase their yields but also by news that source designers are trying to reduce costs. Downward price trends are predicted for all large sources (*5*). The radiation source potentially lowest in cost is a fission-fragment source (*6*).

Cost problems of decontaminating chemical products synthesized with fission-fragment energy may be smaller than people have thought; the reason: a significant fraction of the fission products might be retained by microporous or fibrous nuclear fuels (*7–9*). Along these lines, much attention still goes to nitrogen fixation, a complicated chemical problem that offers a real challenge to the reactor method. Fission-fragment irradiation has produced only low-priced products so far, but a step has been taken in the direction of higher-priced chemicals produced from various organic and aliphatic compounds in simpler chemical reactions (*7*).

Costs may also be reduced by more sophisticated radiation engineering. One Warsaw paper discusses methods of achieving maximum utilization from cobalt, cesium, and sodium-slab irradiators (*10*).

* * *

This is the second of two articles by Mr. Eaton on his impressions of the Warsaw conference, which dealt with applications of large radiation sources. The conference was sponsored by the International Atomic Energy Agency.

BIBLIOGRAPHY

All of the following references are papers presented at the Warsaw conference on applications of large radiation sources, September 8–12, 1959. The authors' countries are indicated in parentheses, and the papers are identified by the numbers assigned to them at the conference.

1. A. Charlesby (UK) unlisted
2. S. Okamura et al (Japan) CW/IIB/33d
3. M. Burton (US) CW/S/66
4. J. Turkevich (US) CW/IIC/48
5. M. Michaelis (US) CW/IIIP/71
6. L. S. Mins (US) unlisted
7. J. K. Dawson, F. Mosely (UK) CW/IP2/24
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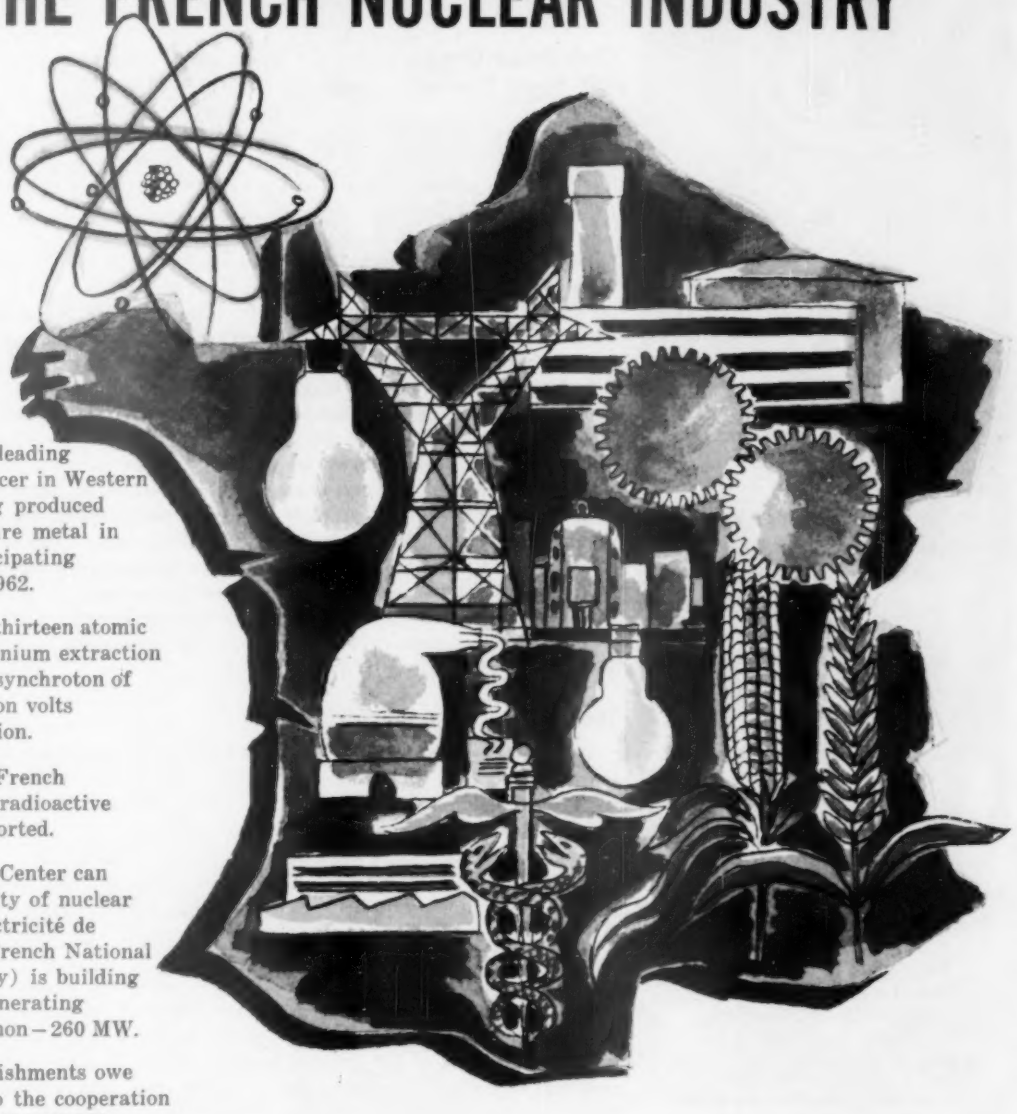

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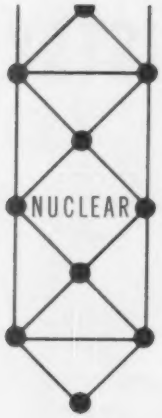

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THERMONUCLEONICS

Oak Ridge Group Still Seeks Burnout

Despite exceeding requirements in the parameters originally thought to be controlling, the DCX (Direct Current Experiment) fusion device at Oak Ridge National Laboratory has not yet reached the critical "burnout" point at which a thermonuclear plasma can be generated. Several solutions for the present difficulties are being explored, and an improved version of the basic device, DCX-2, is on the drawing boards.

The operation of DCX, you will recall, is as follows: A 600-kev molecular hydrogen ion beam is injected from a d-c accelerator perpendicular to a magnetic mirror confining field midway between the two mirrors. Because of the perpendicular magnetic field the beam is bent and, opposite the point of injection, passes through a carbon arc that can, with high probability, cause the molecular ions to dissociate into an atomic ion (H^+) and a neutral atom (H). The neutral is no longer influenced by the magnetic field and flies to the wall of the apparatus along a tangential path; the atomic ion, having half the mass of the molecular ion, moves in a circle of half the diameter of the orbit of the molecular ions and tangent to it at the position of the carbon arc. The atomic ions are trapped in this circle until they exchange charge with residual gas in the vacuum chamber and are themselves neutralized. If the rate of trapping into the circle is higher than the rate at which atomic ions are neutralized, then the concentration of ions in the trapped beam builds up rapidly and a high-temperature fully contained thermonuclear plasma is formed. The lower the background pressure the lower the input current need be; specifically, a background pressure of 10^{-6} mm requires a critical trapped current of about 8 ma for H, about 80 ma for the 2 deuterons that would be used in a true fusion device.

The Quest for Burnout

These two critical experimental parameters were tantalizingly close to the burnout condition at the time of the 1958 Geneva Conference, and there was some hope that that meeting could be told of success. Now, 1½ years later, burnout is still not at hand. What happened?

Well for one thing, the pressure has not been low enough; 2×10^{-7} mm is the best that has been obtained even though the carbon arc itself contributes 8,000 liters/sec of pumping capacity. But this, while it has delayed the achievement of burnout, would not now preclude it because adequate trapped ion currents are now obtainable.

Rather, two new phenomena account for the problem. The first is a spreading of the trapped beam—a spreading that extends clear out to the "necks" of the confining magnetic mirror "bottle" where particles can leak out. It is felt that the spreading of the trapped beam is caused by electrostatic forces generated as a result of collective oscillations in the arc. Just recently the spreading has been reduced drastically by going to stronger magnetic fields, 10–11 kilogauss from about 7 used earlier.

The second difficulty with DCX-1 is that trapped atomic ions are being neutralized by charge exchange with partially ionized carbon atoms in the arc itself. This effect is more important than charge exchange with residual neutral gas at the present time. Several potential resolutions of difficulty are seen:

1. Arc conditions can be improved so that the population of the more highly ionized carbon atoms is greater.

2. One can go over to a new type of dissociation arc, one that operates on hydrogen itself. Such arcs are under development at Oak Ridge.

3. One can use a new mode of operation in which one builds up the trapped beam as much as possible and then switches off the arc so as to eliminate the losses caused by it; then the trapped beam can be expected to burn out on its own.

Thus long-turn hope for the DCX approach rests with DCX-2. One vital feature is that it will be large enough and its magnetic field strong enough to make it possible for the initial beam to pass through the dissociating arc not once but many times; this will improve the trapped current drastically. DCX-2, which would cost about $1-million, has not been authorized yet. Construction would require about eighteen months after that. Meanwhile, improvements in DCX-1 and continuing research into the mechanisms of its operation are providing ever stronger understanding of the device.

RUSSIAN NUCLEONICS

New Numbers for Spontaneous Fission

Of the 2.5×10^{21} atoms in a gram of U^{238}, 31 ± 1.5 undergo spontaneous fission every hour, according to a Soviet experiment. This number is 25% higher than the rate quoted in current reference sources [e.g., Harold Etherington, Nuclear Engineering Handbook, Sec. 2, p. 5 (McGraw-Hill Book Co., New York, New York)] and corresponds to a half-life of $(6.5 \pm 0.3) \times 10^{15}$ yr. The experiments, which used a double-coincidence method, measured the mean number of neutrons emitted per spontaneous fission of U^{238} $\nu = 2.1 \pm 0.1$. The total rate of neutron emission was observed to be (64.5 ± 2.0)/gm/hr; this figure combined with ν gave the spontaneous fission rate. [B. D. Kuzminov, et al, Some features of spontaneous fission of U^{238}, *J. Exper. and Theoret. Physics* **37**, No. 2(8) (Moscow, Aug. 59)]

Analysts Employ 14-Mev Neutrons

Neutron-activation analysis acquires much of its fascination by offering the analytical chemist a vast number of variables to play with and a wide range over which each can be changed. Two investigators have extended the subject by irradiating with 14-Mev *d-t* neutrons. They use a low-energy accelerator, produce fluxes of 10^7–10^8 n/cm²/sec and measure oxygen, phosphorus, silicon, sulfur and chlorine in concentrations of 0.1–1 part per thousand. The principal advantage is time; an analysis takes only a few minutes.

The reactions they use are as follows:

Element	*Reaction*	*Cross section (millibarns)*	*Sensitivity (parts per thousand)*
Oxygen	$O^{16}(n,p)N^{16}$	49	1
Phosphorus	$P^{31}(n,\alpha)Al^{28}$	146	0.1
Silicon	$Si^{28}(n,p)Al^{28}$	220	0.1
Sulfur	$S^{32}(n,p)P^{32}$	369	0.1
Chlorine	$Cl^{35}(n,\alpha)P^{32}$	191	0.1

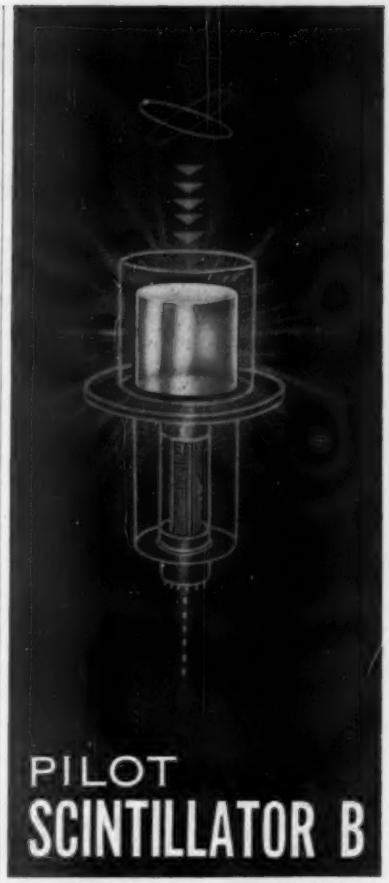
Phosphorus and silicon produce the same nuclide on irradiation; so the analysis is for the two together. The same thing applies to sulfur and chlorine.

N^{16} has too short a half-life (7.3 sec) to permit leisurely analysis. Measurement is by counting its 10-Mev beta particles and observing the decay curve. Oxygen analysis consists in a 15-sec irradiation of sample and standard, 10-sec counts for 1.5 min, subtraction of small long-lived background and comparison of decay curves.

Counting beta particles also sets an upper limit on Al^{28} (2.3-min half-life, 2.87-Mev betas) in the silicon-phosphorus analysis. Sulfur-chlorine analysis requires 12–24-hr irradiations and radiochemical separation of P^{32}. Gamma spectroscopy and greater fluxes are suggested for extension of the method to other analyses. [A. A. Lbov, I. I. Naumova, *Atomnaya Energiya* **6**, 468 (1959) (Translated by Consultants Bureau, Inc., New York, N. Y.)]

Neutron Effects on Ferrites

Russian observations of the behavior of ferrites as memory elements in electromagnetic devices in thermal-neutron fields appear to confirm comparable U. S. results (e.g., NUCLEONICS, June '58, p. 73), although their integrated flux was less by a factor of ten. Ferrites were exposed in a flux of 1.5×10^{13} n/cm²/sec to integrated fluxes of 2.15×10^{17} and 6.5×10^{17} n/cm². Radiation-induced heating caused distortion of the hysteresis loop, as confirmed by control tests at 20°–58.8° C in the absence of radiation, while magnetic properties were independent of the integrated flux. However, loop rectangularity was poorer for the controls. The author suggests this difference may be due to the ordering of the ferrite lattice in the thermal-neutron flux, the mobility of the radiation-induced vacancies and counteraction of the temperature effects by interstitial atoms. Thus, he recommends that ferritic memory elements exposed to neutron and gamma fluxes higher than 5–50×10^{11} n/cm²/sec be provided with an automatic current-regulating device or cooling apparatus. [N. M. Omelyanovskaya, *Atomnaya Energiya* **7**, 66 (1959)] (Translation provided by Tennessee Technical Translators, Oak Ridge, Tenn.)



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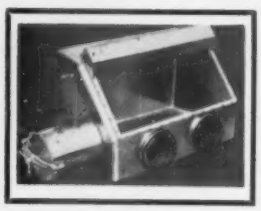

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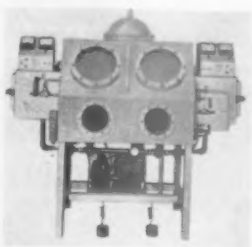

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Flux Perturbation by Detector Foils

(Continued from page 81)

flux perturbation F can be applied with a certain confidence for measurements in a thermal flux. The effect of changes in cadmium ratio deserves investigation and can be expected to be very important. Also, it would be desirable to have more data on the flux perturbation as measured at the boundary between two media (uranium-water, uranium-graphite, etc.). Finally, when the conditions are not easily tractable theoretically (for instance, in a reactor where neutrons have widely distributed energies), the use of a Monte Carlo method might prove to be profitable.

* * *

The author wishes to express his grateful thanks to Mr. W. W. Managan for helpful discussions and for his critical review of this text; to Mr. C. Johnson, who mounted the crystal used in the experiment; to F. Janarek and mainly S. Baker for their help in the experimental work.

Appendix

The perturbation factor as calculated by Skyrme (*8*) for a circular disk is

$$F = 1 - x[\tfrac{1}{2}E_1(x) + A(g) + D_1 - D_1'] \quad (4)$$

where x and g are the foil thickness and radius, respectively, measured in mean-free-path units:

$$E_1(x) = \int_x^\infty \frac{e^{-s}}{s}\,ds$$

$A(g)$ is a function of the foil radius g, which is plotted in Fig. 5. D_1 and D_1' are functions of constants in the medium. Figure 6 is a plot of D_1 against $a\Sigma$ for $L\Sigma$ between 2 and ∞.

a is the foil radius in centimeters; Σ is the total macroscopic cross section of the medium in reciprocal centimeters; and L is the diffusion length in the medium in centimeters. D_1' is not evaluated in detail; however, it is shown that, provided that $a\Sigma > 1$, D_1' is not more than 5% of D_1. When $\Sigma \simeq \Sigma_s$ (Σ_s = macroscopic scattering cross section in the medium) and a/L is small, a simple analytical expression is given for D_1 as

$$\Delta_1 \simeq \frac{4}{\pi} a\Sigma \left(1 - \frac{3\pi}{16}\frac{a}{L}\right)$$

Figure 7 is a plot of $\pi D_1/4a\Sigma$ against a/L for various values of $L\Sigma$; the curve $\pi\Delta_1/4a\Sigma$ is indicated. For $L\Sigma \geq 5$ and $a/L \leq 0.4$, replacing D_1 by Δ_1 is correct within 5%.

The conditions of validity of Eq. 4 are:

- The neutrons are in thermal equilibrium in a medium extending to infinity, with their velocities isotropically distributed.
- $z \ll 1$.
- $z \ll 2g$.

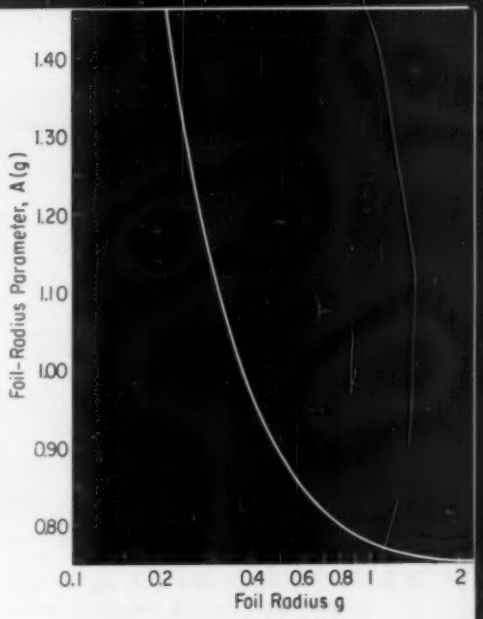


FIG. 5. PLOT OF FOIL-RADIUS PARAMETER A(g) of Skyrme's perturbation formula for circular disk as function of foil radius g

BIBLIOGRAPHY

1. S. M. Dancoff, M. Ginsburg. Surface resonance absorption in a close-packed lattice, CP-2157 (1944)
2. M. W. Thompson. Some effects of the self-absorption of β-rays and neutrons in neutron detecting foils, AERE-RP/R 1549
3. D. H. Martin. Correction factors for Cd-covered foil measurements, NUCLEONICS **13**, No. 3, 52 (1955)
4. C. W. Tittle. Slow neutron detection by foils I (and II), NUCLEONICS **8**, No. 6, 5 (1951); NUCLEONICS **9**, No. 1, 60 (1951)
5. I. E. Dayton, W. G. Pettus. Effective cadmium cutoff energy, NUCLEONICS **15**, No. 12, 86 (1957)
6. W. Bothe. Zur Methodik der Neutronensonden, *Z. Physik* **120**, 437 (1943)
7. G. A. Graves et al. Some foil absorption calculations, LA-1964 (1955)
8. T. H. R. Skyrme. Reduction in neutron density caused by an absorbing detector, MS-91
9. E. Corinaldesi. Sulla misura della densità dei neutroni termici, *Nuovo cimento* **3**, 132 (1946)
10. E. D. Klema, R. H. Ritchie. Thermal neutron flux measurements in graphite using gold and indium foils, *Phys. Rev.* **87**, No. 1, 167 (1952)
11. T. L. Gallagher. Foil depression factors for indium disc detectors (Letter to the Editor), *Nuclear Sci. and Eng.* **3**, No. 1, 110 (1958)
12. A. DeTroyer, G. C. Tavernier. The depression of neutron flux by a foil detector, *Acad. Roy. Sci.* **39**, 880 (1953)
13. S. H. Fitch, J. E. Drummond. Neutron detector perturbations, LRL-95 (1954).
14. R. H. Armstrong, W. L. Kolb, D. H. Lennox. Argonaut, Argonne nuclear assembly for university training, ANL-5704 (1957)
15. G. Pawlicki, private communication (1959)
16. E. Storm et al. Gamma-ray absorption coefficient for elements 1 through 100 derived from the theoretical values of the National Bureau of Standards, LA-2237, p. 85 (1958)

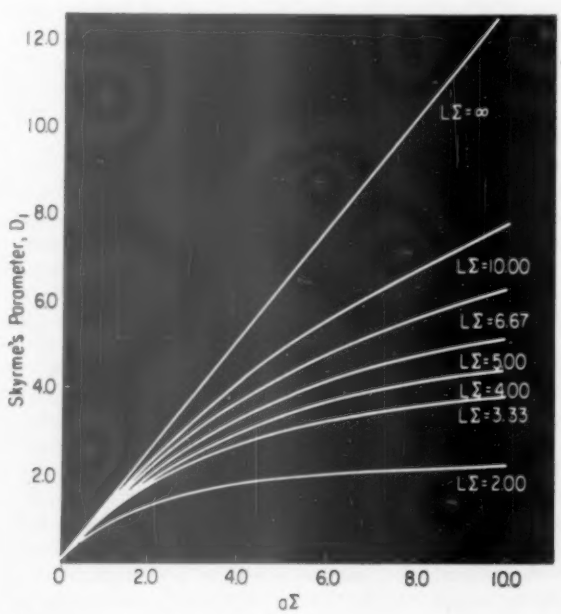
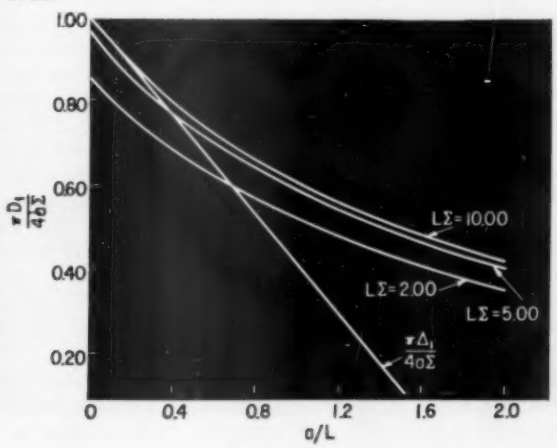


FIG. 6. PARAMETER D_1 of Skyrme's perturbation formula for circular disk as function of $a\Sigma$

FIG. 7. SKYRME'S PLOT of $\pi D_1/4a\Sigma$ as function of a/L for various values of $L\Sigma$



BOOKS

Numerical Methods for Nuclear Reactor Calculations

Supplement Nos. 3 and 4 of *Atomnaya Energiya* (the Soviet Journal of Atomic Energy); translated from the Russian by Consultants Bureau, Inc.

By G. I. MARCHUK (Consultants Bureau, Inc., New York, 1959, 295 pages, $60)

Reviewed by J. CHERNICK, Brookhaven National Laboratory, Upton, N. Y.

As stated in the foreword, this book is "an attempt at a more or less systematic exposition of numerical methods for the calculation of thermal, intermediate and fast neutron reactors." The author has admirably succeeded in this goal, his exposition of numerical methods for reactor calculations being the most complete yet published.

Some of the work is original, having been developed by the author and his colleagues over the years since 1953. The large group of mathematicians and physicists active in this field indicates the keen interest in the U. S. S. R. in matching U. S. techniques for solving reactor problems by means of high-speed computing machines. Marchuk states that the methods developed by his group were first tested on a large quantity of theoretical and experimental data and were later used in operation.

The book is addressed principally to mathematicians. Physical arguments are used only where needed to advance the mathematical text. Results of calculations for specific reactor systems are lacking.

The early chapters of the book are devoted to the development of the multigroup equations for a reactor and their numerical solution by iterative methods. The necessary approximations to the rigorous Boltzmann equation are introduced in logical steps, the diffusion-age approximations being developed in the second and third chapters. Refinement of slowing-down theory is discussed in chapter 4, and a proof of the convergence of the method of successive approximations for bare reactors is given in chapter 5. The method of groups is then introduced, and the basic reactor equations are set down for both weak and "strong" absorption of slowing down neutrons. Chapters 8 and 9 treat the diffusion equations in finite-difference form and the various methods of solving them. The novel method of matrix factorization for two-dimensional regions is discussed in chapter 9, although it is conceded that more usual iteration procedures are frequently more convenient.

The later chapters of the book are devoted to special topics. Chapter 12 reviews U. S. S. R. work on the resonance absorption of neutrons and boundary conditions for control rods. Fast-reactor equations are treated in chapter 13 and a chapter on hydrogen-moderated reactors was added to the book after the manuscript had been prepared for publication.

The reviewer was impressed with the thoroughness and skill of the author's presentation. The adjoint reactor equations are applied throughout the text with originality and effectiveness. Similarly, perturbation theory is skillfully developed while its limitations are clearly recognized and defined.

In short, the book should appeal not only to the applied mathematician, who is involved in reactor calculations, but also to the general reactor physicist or engineer. It is unfortunate that the price of the book will preclude more than one copy at most institutions.

Theorie der Thermischen Kernreaktoren

By A. D. GALININ (B. G. Teubner Verlagsgesellschaft, Leipzig, Germany, 1959, xii + 382 pages)

Reviewed by T. AUERBACH, Reactor Theory Group, Brookhaven National Laboratory, Upton, N. Y.

The results of Soviet research in the field of reactor theory have so far diffused only slowly into the Western world. While we have developed our own school of reactor physics, the Russians have developed theirs, and it is therefore not surprising that differences in approach have come into existence. This fact, plus the adequacy of our theory for our own purposes, have resulted in a widespread lack of familiarity with the Russian literature. For this reason, as well as by reason of its thorough treatment of the subject, the book under discussion will form a valuable addition to the still small family of representative texts on reactor theory. This German edition is a translation of the original Russian.

The main emphasis throughout the book is placed on problems connected with actual reactor design. While the treatment of theory is careful, it is also very compact, and the chief aim evidently is to compress a maximum of useful knowledge into the relatively limited space of 360 pages. As a result, the book is by no means an elementary text, but requires considerable familiarity with the subject. To save space, the author has frequently abbreviated the mathematical treatment, in some instances only quoting the results. On the other hand, throughout the book the reader is always kept in close touch with the physics of the problem.

An Introduction to Thermonuclear Research

By ALBERT SIMON (Pergamon Press, New York, 1959, 182 pages, $5.50)

Although based on lectures given in the fall of 1955, this text can provide a useful introduction to the problems of controlled fusion for those who have had no previous acquaintance with the subject. The energetics and cross sections of the fundamental fusion reactions are discussed along with the basic conditions for a fusion reactor, after the fashion of R. F. Post's well-known review article. The properties of charged particles in magnetic fields are treated in general and then in the context of three specific types of machines, the Stellarator, the mirror machine and pinch devices. Finally, some of the problems of stability and of diffusion in a magnetic field are considered. The treatment is not deeply mathematical, though this is a more quantitative book than, say, Bishop's Geneva review.—DIC.

Geneva '58 Proceedings

Other volumes have been described beginning with the July NUCLEONICS. **Vol. 9, Nuclear Power Plants, Part 2** (538 pages, $17.50), is oriented mainly toward reactor concepts, whereas specific power reactors were described in Vol. 8. Power-reactor papers (session B-9) are grouped as water, boiling-water, organic-cooled, gas-cooled, liquid-metal-cooled and homogeneous reactors. Power reactor experiments (session B-10) are grouped as water, boiling-water, gas-cooled, liquid-metal-cooled and homogeneous or fluid-fuel reactors. Session B-11 includes the first group of papers on reactor experi-

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Vol. 16, Nuclear Data and Reactor Theory (744 pages, $18.50), presents the basic data and methods of reactor physics. Session A-11, Nuclear Data, provides a good review of cross sections data and theory pertinent to nuclear reactors. Session A-12 deals largely with reactor spectra and thermalization. Session A-13, Reactor Theory and Computing Methods, begins with a paper by Marchuk et al. on "Reactor Calculation Methods," followed by over 40 other papers on such subjects as neutron scattering, diffusion, flux, self-shielding and multiplication.

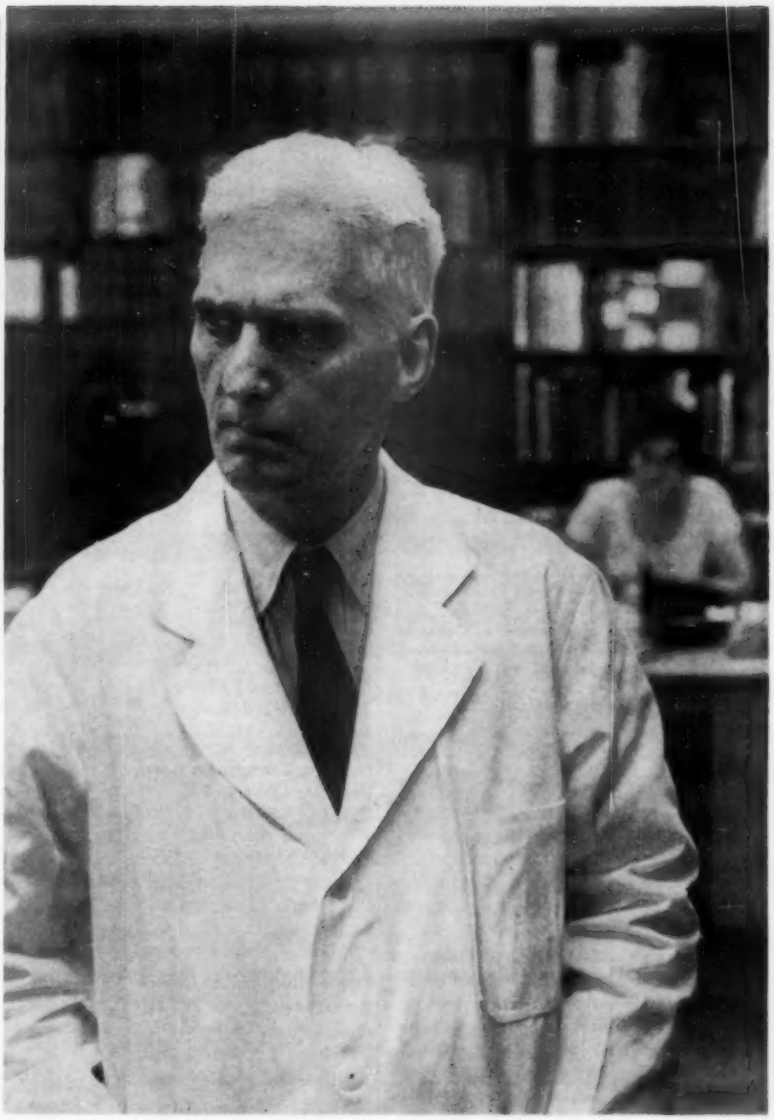
Vol. 27, Isotopes in Agriculture (455 pages, $14), covers the use of isotopes for studying plant and animal physiology and soil studies in session D-21. Session D-22, Genetics and Crop Improvement, includes papers on genetic effects of radiation, sterilization and food processing.

BOOKS RECEIVED

Dosimetrie und Strahlenschutz, by R. G. Jaeger, is a handbook for radiation physicists and radiologists containing a bibliography, definitions and data. *Georg Thieme Verlag, Stuttgart, Herdweg 63, Germany, 1959, 282 pages, $11.80.*

Encyclopedic Dictionary of Electronics and Nuclear Engineering, by R. I. Sarbacher, contains 14,000 entries and over 17,000 cross-references in the closely related electronic and nucleonic fields. Clearly written in considerable detail, this book should be useful to someone with an interest in areas allied to his specific work. Included are a table of reactors, descriptions of reactor types, nuclear physics, reactor-fuel processing, AEC and industrial projects, etc. Basic equations and data are frequently given, as well as numerous standard electronic circuits. *Prentice-Hall, Englewood Cliffs, N. J., 1959, 1417 pages, $35.*

International Directory of Radioisotopes, Vol. 2, published by the International Atomic Energy Agency, contains information on chemical compounds labelled with C^{14}, H^3, I^{131}, P^{32} and S^{35}. Compounds are listed alphabetically for each isotope and indexed by synonym. Suppliers are also listed. *$3.00. U. S. distributor: International Publications, Inc., New York.*



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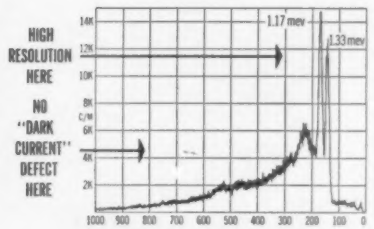
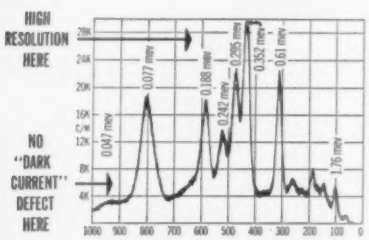


Actual spectrogram of Cobalt-60 made with a GSS-1. Window No. 3. Time constant: 2 sec.

A complete gamma spectrometer system NMC model GSS-1 ($4,180 fob, Indianapolis)

This greatly simplified system features regulated high voltage supply as part of the counting ratemeter auto-scan system . . . all-transistorized probe amplifier and spectrometer circuits . . . and solid or well-type crystal. These points and the actual spectrograms shown here tell only part of the story. For full details, write or phone collect.



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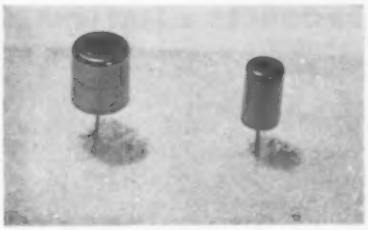
PRODUCTS AND MATERIALS

New Labeled Compounds

Radioisotope-labeled compounds introduced for sale during the preceeding quarter by various suppliers are listed below. NUCLEONICS will carry this listing on a quarterly basis.

Supplier	*Compound*
Isomet Corp. 433 Commercial Ave. Palisades Park, N. J.	urea-N^{15} glycine-N^{15} O_2 (to 2.5 atom % O^{17}) O_2 (to 95 atom % O^{18}) methanol-C^{13}
Merck & Co., Ltd. 560 De Courcelle St. Montreal, Canada	methyl-C^{13} acetylene pyridine-α-C^{14} butyronitrile-1-C^{14} acrylonitrile-2-D durene-D_{14}
New England Nuclear Corp. 575 Albany St. Boston 18, Mass.	cholesterol-26-C^{14} potassium cyanate-C^{14} *d*-glucose-1-H^3 estrone-6,7-H^3 aniline-H^3 hydrochloride
Nuclear-Chicago Corp. 359 E. Howard Ave. Des Plaines, Ill.	adenosine-8-C^{14} α-aminoisobutyric-1-C^{14}
Nuclear Consultants Corp. 9842 Manchester Rd. St. Louis 19, Mo.	$Cr_2P^{32}O_4$ tetraiodophenolphthalein-I^{131}
Nuclear Corp. of America P. O. Box 688 Burbank, Calif.	α-aminoisobutyric acid-1-C^{14} allyl alcohol-1-C^{14} 5-bromouracil-2-C^{14} malonic acid-2-C^{14} hexadecane-1-C^{14}
The Radiochemical Centre Amersham Buckingham, England	sodium borohydride-H^3 pyridoxin-H^3 hydrochloride methane sulphonyl-S^{35} chloride saccharin-S^{35} di-isopropylfluorophosphonate-P^{32}
Research Specialties Co. 200 S. Garrard Blvd. Richmond, Calif.	1-butene-1-C^{14} hexamethyl-C^{14} benzene 4-(2,4-dichlorophenoxy) butyric-1-C^{14} acid tripalmitate glycerol-1,3-C^{14}
Schwarz BioResearch, Inc. 230 Washington St. Mount Vernon, N. Y.	*l*-histidine-T
Tracerlab, Inc. 1601 Trapelo Rd. Waltham 54, Mass.	acetone-1,3-C^{14} bromoacetic acid-1 and -2-C^{14} malonic acid-1,3-C^{14} propylene-1-C^{14} tristearin carboxyl-C^{14}
U. S. Nuclear Corp. P. O. Box 208 Burbank, Calif.	glycerol-2-C^{14} benzylamine-7-C^{14} benzamide-7-C^{14} Octoil S C^{14} hexadecane-1-C^{14}
Volk Radiochemical Co. 5412 N. Clark St. Chicago 40, Ill.	*dl*-*p*-fluorophenylalanine-3-C^{14} sodium bicarbonate-C^{14} iodoacetamide-1-C^{14} *l*-triiodothyronine-I^{131} *l*-thyroxine-I^{131}

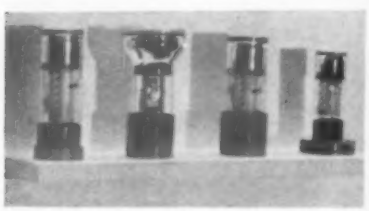


Semiconductor Detectors

Silicon-junction detectors (NU, Feb. '60, 54) capable of detecting alphas and other heavy particles with excellent linearity and resolution of 1% at 5 Mev are now available commercially. Types A and C are 0.225-in. dia. and take the form shown on the right above. Types B and D, shown on the left, are 0.340-in. dia; specs for these are incomplete. Tentative specifications for types A and C follow:

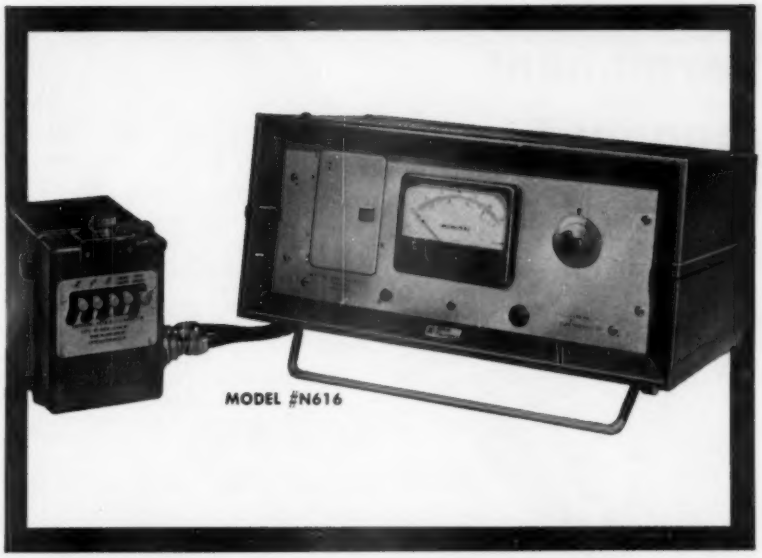
	Type A	*Type C*
Detecting area	5 mm²	20 mm²
Max. operating bias	50 v	50 v
Min. detectable α energy	<1 Mev	<1 Mev
At 50-v bias:		
Leakage current	<1 $\mu\alpha$	<2 $\mu\alpha$
Signal-to-noise for 5-Mev α	>50	>25
Resolution for 5-Mev α	<2%	<3%
Range over which response to α is linear within 5%	2–10 Mev	2–10 Mev
Capacitance	25 $\mu\mu f$	60 $\mu\mu f$
Pulse rise time	12 mμ sec	—

—Research Laboratories, RCA Victor Co., Ltd., Montreal, Canada.



New Photomultipliers

Integrated research, development and manufacturing facility has begun production of photomultipliers and specialized cathode-ray tubes. The end-on multiplier tubes have linear dynode structures of special design. Faceplate is plano-concave with photocathode deposited on curved surface to ensure excellent uniformity of response across face of the tube. Extremely short transit-time spread results from use of curved photocathode in conjunction with linear multiplier structure. Available 10-stage tubes include



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PRODUCTS & MATERIALS

Department starts on page 146

1½-, 2- and 3-in.-dia S-1 response tubes, 1½-, 2- and 3-in.-dia (5-in.-dia in development) S-11 response tubes, and 2-in.-dia tubes with Rb_2Te and Cs_2 cathodes. A 2-in.-dia high-gain 14 stage S-11 response tube is being developed. Many of the photomultipliers are interchangeable with comparable existing tubes.—CBS Laboratories, High Ridge Rd., Stamford, Conn.

Scaler Ratemeter

Model 555 scaler ratemeter (above) combines an advanced scaler, ratemeter, integral analyzer, spectrometer-quality high-voltage supply and audible howler in one chassis.—Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.

Medical Ratemeter

Dual-channel logarithmic counting-rate meter system shows amount of radioactivity in two organs or regions and shows ratio between the two on three separate gages. Activity of both areas is recorded on a dual-channel recorder.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Continuous Air Monitor

Continuous, automatic air monitor records total radioactivity immediately; after adjustable time delay (up to 3 days) sample is remeasured for residual, long-life activity. Tape speeds and measuring ranges are adjustable.—Kahl Scientific Instrument Corp., P. O. Box 1166, El Cajon, Calif.

Detector; Spectrometer

Eleven interchangable detection heads can be used on transistorized scintillation detector that has a long (>150 v), flat (<5% slope/100 v) plateau. Amplifier and corona regulator can be bypassed when unit is used with linear amplifier for γ spectrometry.

Auto-step spectrometer has stepping-motor drive to advance threshold

setting in 100 discrete 1-v increments. Scaler records counts at window; data printer prints window number, number of counts and elapsed time.—Tracerlab, Inc., 1601 Trapelo Rd., Waltham 54, Mass.

Proportional-Counter Converter

Proportional-counter converter connects to G-M input of any scaler which can then measure α, β and γ radiation. Every α and β disintegration is counted.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Airborne Survey Meter

Battery-operated survey meter is designed for airborne applications and indicates full scale values to 500 mr/hr, dose rates up to 500 r at max rate of 500 r/hr.—Franklin Systems, Inc., 2734 Hillboro Rd., West Palm Beach, Fla.

High Volume Air Sampler

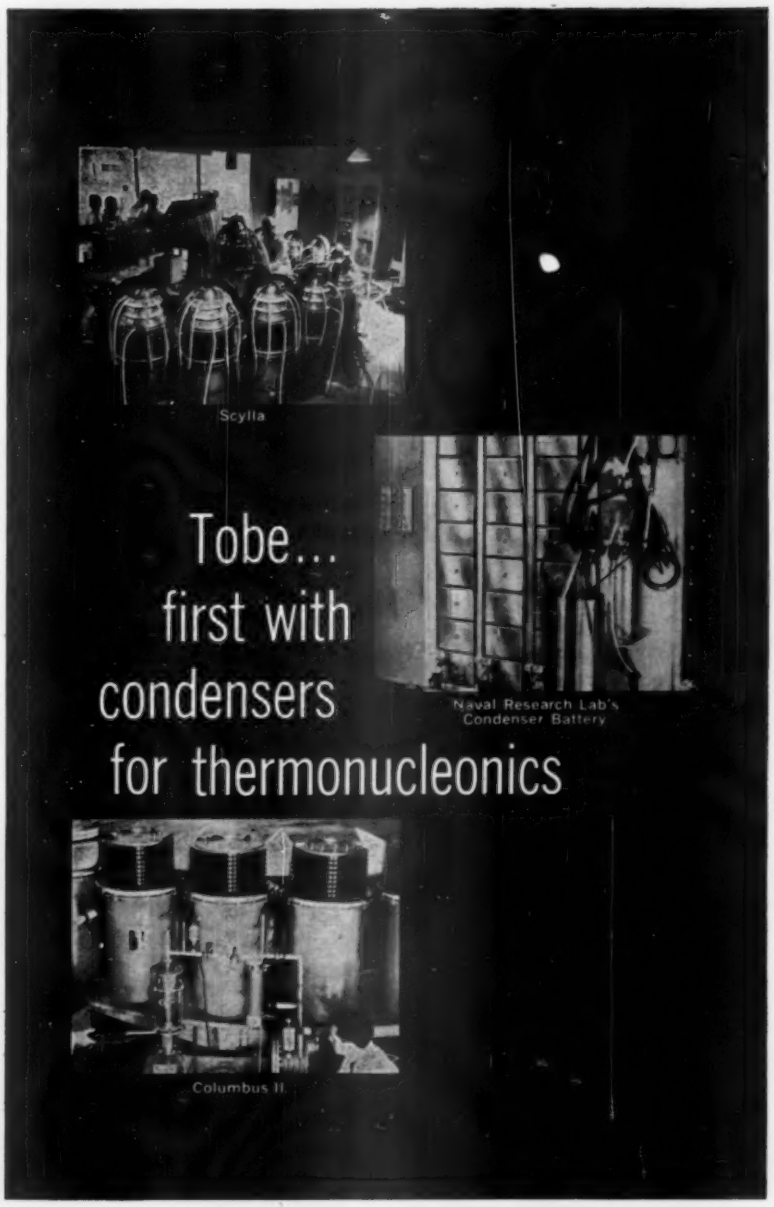
Air sampler with 4-in.-dia filter head has sampling rates up to 100 cfm and is driven by 0.5-hp motor.—Gelman Instrument Co., Chelsea, Mich.

Transistorized Well-Counter

Model SC-57A well-type scintillation detector (above) employs a ½-in.-dia gamma-well crystal that accepts standard 5-ml sample vials. Background is ~100 cps; stability and low noise level are facilitated by external mounting of transistorized pulse amplifier. Efficiency for I^{131} is ~45%.—Tracerlab, Inc., 1601 Trapelo Rd., Waltham 54, Mass.

Multipower Ultrasonic Cleaners

New transducer, which provides more intense vibrations, is featured in new line of cleaners. Transducer is piezoelectric ceramic compressed between



Of particular interest to the thousands of international visitors to the historic Geneva Atoms-For-Peace Conference, was the display of thermonuclear fusion research equipment which the U.S. Government set up. Significantly, several of these devices use Tobe low-inductance condensers. Three of the machines are shown here.

Even now – long after the conference – inquiries and orders are being received from every corner of the globe. The postmarks read like a roll call at the United Nations: Great Britain, Japan, Italy, U.S.S.R., France, Brazil, The Netherlands, Sweden and many others.

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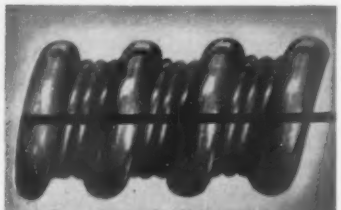
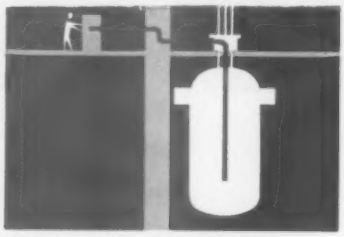


Electrical Lead Cable transmits electrical signals through insulated wires stranded in cable core—eliminates external electrical wires. Thermocouples, electro-magnets, ion-chambers are easily moved and replaced.



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two metal sections. Models include: 250 w (3-gal tank), 500 w (5-gal tank) and generator producing av of 1,000 w (10-gal tank).—Acoustica Assoc., Inc., Plainview, L. I., N. Y.

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Ultrasonic cleaner delivers average output of 125 w and peaks of 500 w. Bottom of 2-gal tank is 27% covered with driving elements; actual radiating surface is 24 in². —National Ultrasonic Corp., 111 Montgomery Ave., Irvington 11, N. J.

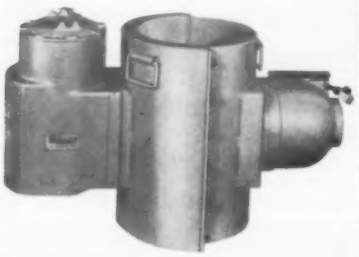
Two Automatic Spectrometers

Model SS-1 γ spectrometer (above) automatically scans pulse-height spectrum from 100% down to 0% by using low-level reset and upper-level discriminator control. Window width is adjustable from 0 to 10 v. Model ASP-1ADR automatic single-channel spectrometer is a print-and-plot type that presents data in both digital and analog forms. Counting time for full scans is variable from 1 to 100,000 cpm. —The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

Stainless Castings

Forty-two cast stainless-steel transition pieces (above) will be used in the

Indian Point reactor. Each casting is 38 in. long, weighs ~180 lb and is cast from type CF-8 (Alloy Casting Institute designation) stainless. Complex part, which has cross-shaped slots at one end and round opening at the other, is a single, integral piece.—The Babcock and Wilcox Co., 161 E. 42nd St., New York 17, N. Y.



Density Gages

Models LRV and LR gamma density gages (above) can be built into lines or bolted to existing piping. Model LR uses electrical zero suppression and model LRV uses a patented, zero-compensating cell. Measurement spans down to specific gravity of 0.05 are attainable on 16-in. pipes.—The Ohmart Corp., 2236 Bogen St., Cincinnati 22, Ohio.

1720-lb Permanent Magnet

A 1720-lb Alnico V permanent magnet (above) (said to be world's largest) will help pump liquid sodium in the Experimental Breeding Reactor II. Permanent magnet is used since magnet will be completely surrounded by liquid sodium. Gap length is 16½ in., volume is 1,584 in.^{3} and density at center is 1,100 gauss.—Allegheny Ludlum Steel Corp., Oliver Corp., Pittsburgh 22, Pa.

Burnable-Poison Strips

Burnable-poison strips ranging from $\frac{1}{16} \times \frac{1}{4}$ in. with 0.010-in. cladding to $\frac{1}{2} \times 2$ in. with 0.012-in. cladding are available in lengths from 10 to 42 in.

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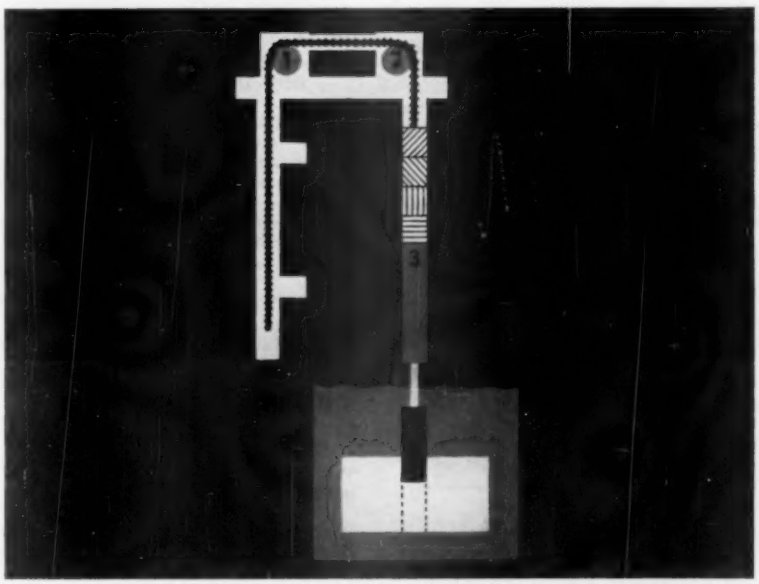

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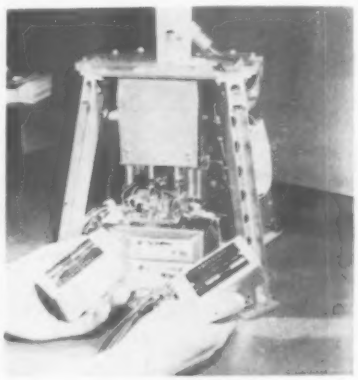
B_4C containing 18.5 wt% B^{10} is used in a matrix of Zircaloy-2 powder that is 60 mesh or finer. B_4C content of matrix and cladding is 1–6.5 wt%.—Nuclear Materials and Equipment Co., Apollo, Penna.

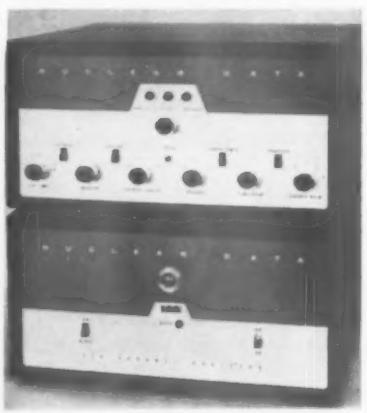
Pressure Transmitter

Bellows-type differential-transformer pressure transmitters are available for pressure ranges 0–500 psi, 0–1,500 psi and 0–2,000 psi. Accuracy is ±0.75%.—Consolidated Controls Corp., Bethel, Conn.



Miniature Power Supply

Model 61-R miniature, transistorized power supply (above) has output of 900–1,200 v d-c. Max. current varies from ~80 μamp at 900 v to 50 μamp at 1,200 v. Input is 6 v d-c. Unit weighs 7 oz.—Components Corp., Nuclear Instrument Div., Denville, N. J.



256-Channel Analyzer

256-channel analyzer (above) features total weight of 35 lb, volume of 1 ft^3 and 12 w power consumption for analyzer and readout unit permitting

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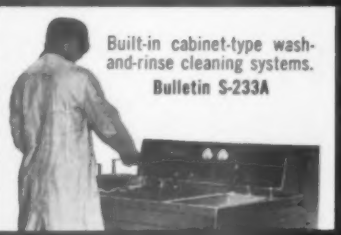

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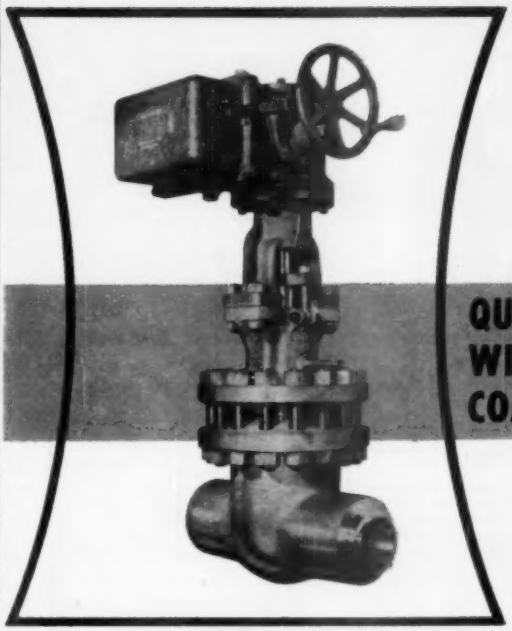

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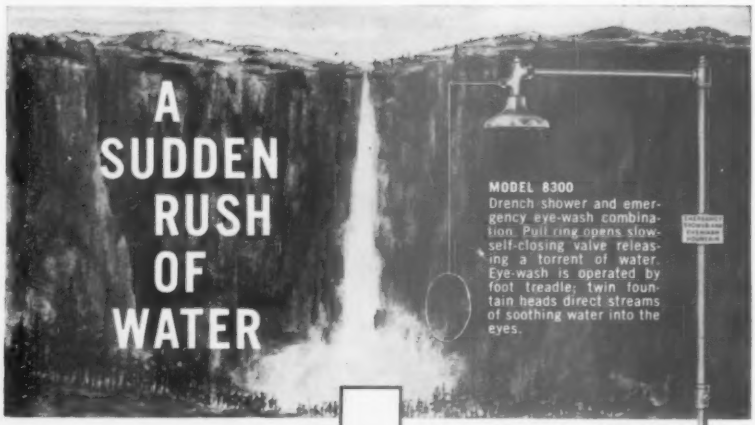
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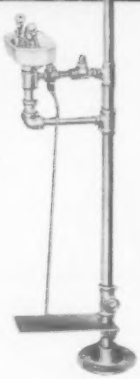

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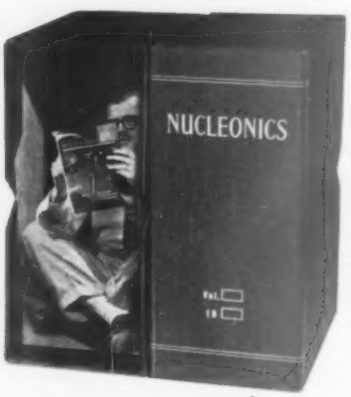

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PRODUCTS & MATERIALS

Department starts on page 146

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Titanium carbide, tungsten, chromium, titanium and many other materials can be deposited on most ceramic-base materials or metals without metallurgical, crystallographic or chemical changes with hand-held spray gun (above). Gun weighs <4 lb and can operate on A, N and other gases at power levels to 40 kw.—Giannini Plasmadyne Corp., 3839 S. Main St., Santa Ana, Calif.

Conductivity Bridge

Electrolytic conductivity bridge, which can also be used for resistance measurements, has dual calibrations that permit readings of resistance over a range from 0.2 to 2.5×10^6 ohms and conductance from 0.4 to 5×10^6 ohms. Bridge circuit voltage is 1,000 cps.—Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.

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Differential Scanner

Model VLS differential scanner permits separation of background radiation from radiation of ore face or stock pile. One count is made with light shield inserted between crystal and photomultiplier; a second count is made with the shield removed. Percent of contained uranium can then be calculated.—Uranium Instruments Co., Box 1191, Grand Junction, Colo.

Neutron-Detector Tube

Neutron detector tube that can be used with standard photomultiplier tube circuitry has cascade-type cathode with neutron-sensitive coating deposited internally on window. The multiplier tube is 2-in. high-gain, 10-stage, end-window type.—Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N. J.

Centrifugal Transfer Pump

Model El-10 centrifugal pump is specifically designed for transferring corrosive liquids and solvents without leakage. Motor rotor and stator are isolated from pumping chamber by 316 stainless-steel canning; pump is magnetically driven by motor. Maximum flow with water is 20 gal/min and max head is 25 ft.—Sethco Manufacturing Co., 2284 Babylon Tpk., Merrick, N. Y.

Portable Recorder

Portable potentiometer recorder has 6-in. chart and compactness permits up to 4 recording channels to be mounted in 19-in.-wide rack. Instrument has 9–120-mv span, 0.8-sec balance time and ¼% sensitivity.—Systron Corp., 950 Galindo St., Concord, Calif.

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PRODUCTS & MATERIALS

Department starts on page 148

3,400° F and can be sawed or cut.—Ipsen Industries, Inc., 715 Main St., Rockford, Ill.

Gamma Spectrometer

Model GSS-1 gamma spectrometer system is sliding-pulse type in which pulse is brought to window rather than window to pulse. Spectrometer circuit is all-transistorized and 2- × 2-in. NaI scintillation crystal is used with spectrometer-grade photomultiplier.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Ultrasonic Flaw Detector

Test signals which appear within preset limits are detected by flaw alarm which then actuates recorders or warning devices. Model A flaw alarm, a pass/reject indicator, has panel-light and d-c signal outputs. In Model B, d-c output is variable proportional to size of flaw; amplitude of flaw can be recorded. Model C permits recording of flaws at pulse-repetition rate which is variable from 100 to 600 pulses/sec.—Branson Instruments, Inc., 40 Brown House Rd., Stamford, Conn.

Dust Hood

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Radiation Warning Device

Radiation warning instrument sounds loud signal when dose rate of 2.5 mr/hr is exceeded. Adjustable for warning at higher dose rates, the device is 4 × 3 × 1½ in. and weighs 8 oz.—Radiation Recording Instruments, P. O. Box 1056, Stn. B, Montreal 2, Canada.

LITERATURE AVAILABLE

Electronic high-vacuum pumps. 2 pp.; Ultek Corp., 920 Commercial St., Palo Alto, Calif.

Oscilloscope camera. 1 p.; Hewlett-Packard Co., 1014A Page Mill Rd., Palo Alto, Calif.

Germanium and silicon transistors. Brochure G-200, 15 pp.; General Transistor Corp., 91–27 138th Place, Jamaica 35, N. Y.

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Low background system. 2 pp.; Atomic Accessories Inc., 811 W. Merrick Rd., Valley Stream, N. Y.

Dual channel logarithmic C-R meters. 2 pp.; Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Anticoincidence preamplifier. 4 pp.; Smith-Florence Inc., 4228 23rd Ave. West, Seattle 99, Wash.

Electrometers, μμammeters, other instruments. 1960 Catalog, 31 pp.; Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio.

Electronic thermometer. Technical Bulletin 140; Trans-Sonics, Inc., Burlington, Mass.

Atomic instruments and systems. Catalog A-4; Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.

Facilities brochure. Pottstown Metal Products Div., Cochrane Corp., Philadelphia, Penna.

Density gage, for 4–14-in. pipes. Bulletin LSG, 2 pp.; The Ohmart Corp., 2236 Bogen St., Cincinnati 22, Ohio.

Gamma radiation ratio computer. 4 pp.; Radiation Counter Laboratories, Inc., Nucleonic Park, 5121 W. Grove St., Skokie, Ill.

Nuclear Instrumentation. 4 pp.; Radiation protection service. 4 pp.; Nuclear-Chicago Corp., 332 Howard Ave., Des Plaines, Ill.

Startup channel. Catalog DS 400 A, 8 pp.; Bendix Aviation Corp., 3130 Wasson Rd., Cincinnati 8, Ohio.

High-voltage measuring gear. 8 pp.; Miles Hivolt, Ltd., 13 Mortimer Rd., Hove 3, Sussex, England.

Multistage sealless centrifugal pumps. Bulletins 1020-2 and 1100, 2 pp.; Chempump Div., Fostoria Corp., Huntingdon Valley, Pa.

31-Mev betatron. 14 pp.; U. S. A.: Curtiss-Wright Corp., Princeton Div., Princeton, N. J. Foreign:

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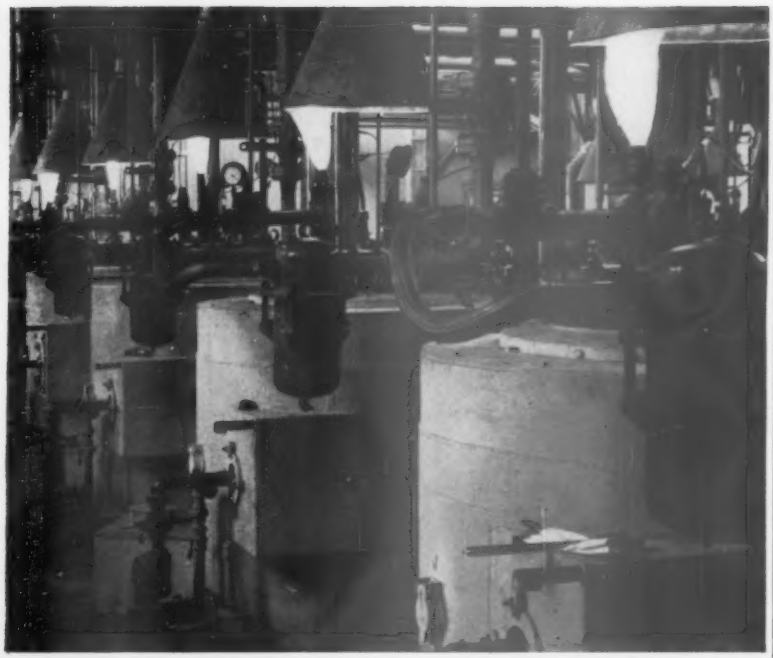

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Ultrasonic equipment cleaning. 2 pp.; nondestructive testing, 4 pp.; Curtiss-Wright Corp., Princeton Div., Princeton, N. J.

Anticoincidence preamplifier. 4 pp.; Smith-Florence Inc., 4228 23rd Ave. W., Seattle 99, Wash.

Profile monitor. PM 2-917, 2 pp.; Advanced Technology Laboratories, Div. of American Standard, 369 Whisman Rd., Mountain View, Calif.

Stainless-steel planchets. 1 p.; Planchets, 1035 N. Fletcher Rd., P. O. Box 216, Chelsea, Mich.

Radiation-detection gear. Catalog I-60, 36 pp.; Nuclear Measurements Corp., 2460 N. Arlington, Indianapolis 18, Ind.

Teflon shaft seals. Bulletin S-233; Crane Packing Co., Ltd., Dept. NC-6, Box 134, Station C, Hamilton, Ontario.

Ferrite-plate memory stacks. 2 pp.; Rese Engineering, Inc., 731 Arch St., Philadelphia 6, Penna.

Coincidence analyzer. 2 pp.; High-stability power supply. 2 pp.; Interstate Electronics Corp., 707 E. Vermont Ave., Anaheim, Calif.

Small strip-chart recorder. Bulletin 190(9-59), 2 pp.; Westronics Inc., 3605 McCart St., Fort Worth, Texas.

Thermocouples, packed and spring-loaded. S 001-1a, 4 pp.; Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa.

Millimicrosecond quantizer. Bulletin 104a, 2 pp.; Computer Equipment Corp., 1931 Pontius Ave., Los Angeles 25, Calif.

Gold-bonded Ge diodes. Brochure GD-40, 10 pp.; General Transistor Corp., 91-27 138th Place, Jamaica 35, N. Y.

Magnetic recorder. Bulletin FR-100B, 19 pp.; Ampex Corp., 934 Charter St., Redwood City, Calif.

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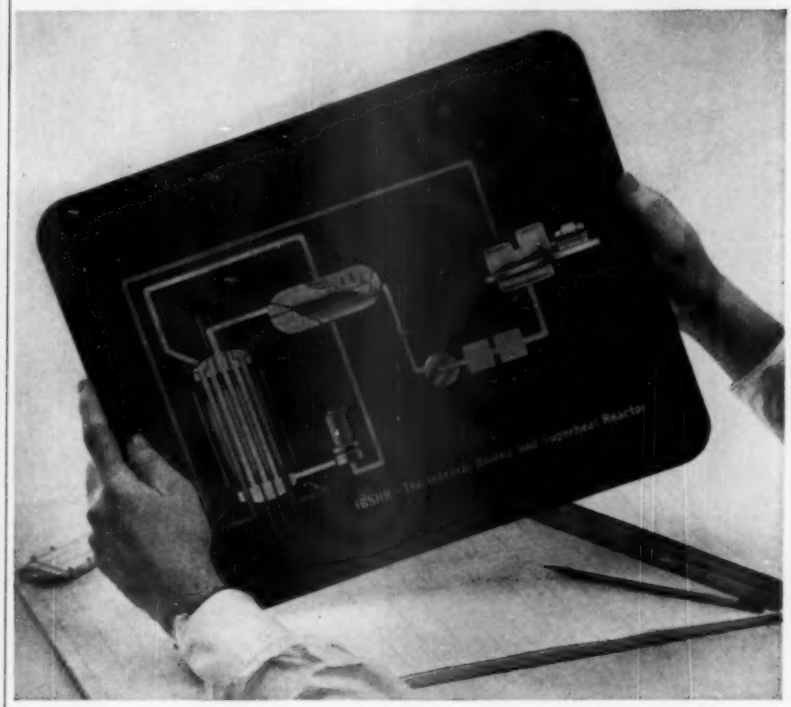

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INDUSTRY NOTES

● AEC's New York Operations Office, central contractor for AEC and its contractors on the recovery of **unirradiated uranium scrap,** said last month it had awarded ten contracts worth about $180,000 under the program. Another $75,000 in scrap-recovery business was expected from its most recent invitation to industry bidders. AEC officials said the program was making an important contribution to the development of "a strong competitive domestic uranium scrap industry."

● AEC has extended E. I. du Pont's contract for operation of the **Savannah River plant** to June 30, 1964; du Pont gets no fee but AEC covers all costs (about $100-million yearly).

● The **Wolverine Tube div.** of Calumet & Hecla said it has produced seamless tantalum tubing in lengths up to 60 ft (heretofore only much shorter lengths had been possible). First major user of the long tubing, the firm said, will be AEC's Ames Laboratory, Iowa State Univ.—for the construction of molten-metal test loops.

● AEC's price for the stable isotope **helium-3** has been reduced by 90%—from $1.50 to 15 cents/cubic centimeter. An important research tool, He^3 is used in high-energy reactions and for producing low temperatures (within 0.3 degrees of absolute zero). Oak Ridge National Laboratory, AEC's marketer, has distributed 150,000 cm^3 He^3 over the last 18 months.

● **Gladding, McBean & Co.,** active in several nuclear areas, including fuel elements, fusion and wastes, has leased a 15,000-sq-ft plant in Monrovia, Calif., for expansion of its new Technical Ceramics div. The plant went into operation in early February.

● **A Texas uranium mill,** Falls City, is planned by Susquehanna-Western, Inc. of Denver. The company was completing negotiations with AEC for purchase of the plant's yellowcake; ore throughput will be 200–250 tons U ore/day.

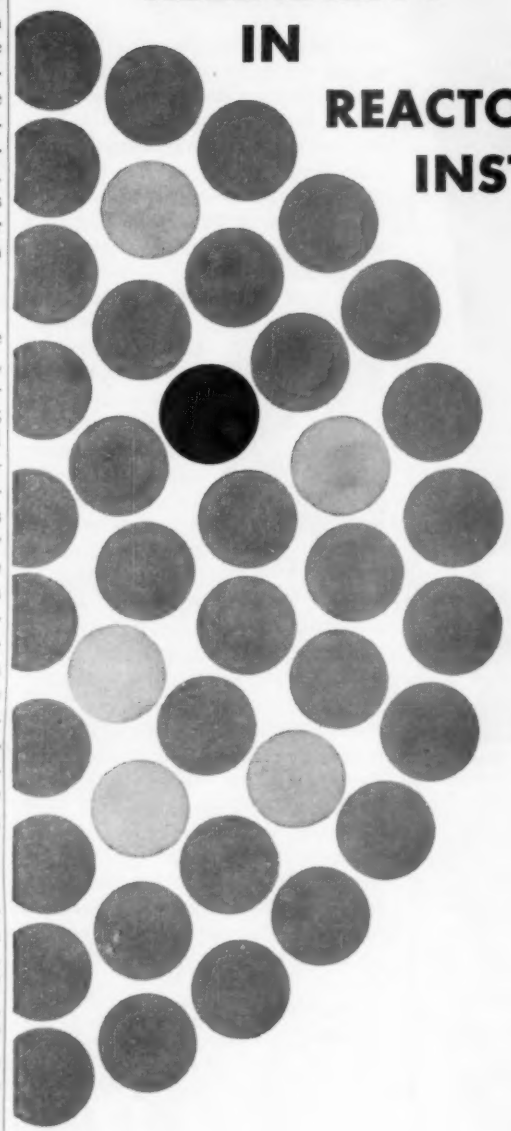
AGENCY NEWS. The French firm **Intertechnique** reports sales of $1.5-million in nucleonic instruments last year, the largest part of it being multichannel analyzers produced in France under

license from **Radiation Instrument Development Laboratory,** Chicago. Intertechnique's R. Cohen is European liaison manager for RIDL. . . . The **Atomic Associates** subsidiary of **Baird-Atomic** has been named exclusive marketing agent for a subcritical training reactor manufactured by **Curtiss-Wright.** . . . Milwaukee's **Durant Mfg. Co.,** maker of industrial counters, has established a West Coast repair center at **Pacific Coast Instrument Co.,** San Francisco.

NEW BUSINESS. The Air Force has given **Nuclear Engineering Co.,** Pleasanton, Calif., a world-wide contract for disposal of radioactive waste; the contract is open with estimated cost to the AF ranging from $30,000–$100,000. . . . The National Aeronautics and Space Administration has given the **Naval Research Laboratory** a $50,000 contract to study the thermodynamics of sodium at high temperatures for possible use in nuclear-electric power generating systems. . . . **Tracerlab** has a contract from the Air Force to investigate X-rays for possible use in space communication. . . . An unspecified federal agency has given **Oregon Metallurgical Corp.** a $430,000 contract for high-purity vanadium, a metal with low neutron cross section.

FINANCIAL. Fresh from its announcement of its fifth acquisition in less than a year (the assets of National-U. S. Radiator Corp.), **Crane Co.** of Chicago disclosed a $45-million, seven-year credit agreement with a group of 17 banks; $20-million will be used to close the National-U. S. Radiator purchase, the rest for capital and expansion over the next 19 months. . . . **Baird-Atomic** reported record shipments for the quarter ended Dec. 31 ($2.9-million). Earnings remained relatively low ($85,000 or 7 cents/share) but were more than double the $37,000 earned in all of fiscal 1959, ended last September. B-A predicted fiscal 1960 shipments of $11-million-plus. . . . **Electric Boat div.** of General Dynamics accounted for 10% of the firm's total defense-contract awards of $1.6-billion in the fiscal year 1959, ended last June 30 . . . **Beryllium Corp.** reports a demand for beryllium metal so high that it "requires expansion in production capacity several times that of our present output." Its Hazelton, Pa., nuclear facilities will be "substantially" enlarged, the firm said.

RELIABILITY IN REACTOR INSTRUMENTS



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NEWSMAKERS—

George B. Foster, vice-president and technical director of Industrial Nucleonics and one of its three founders, has left the firm. However, he still holds a substantial interest in Industrial Nucleonics and remains on the board of directors. He resigned to establish his own research firm, Foster Engineering Co., also in Columbus (Ohio).

Joseph W. Ranftl, a key figure for several years in the marketing of resonant transformers by General Electric's X-ray dept., Milwaukee, has joined the American Nuclear div. of American Electronics, Culver City, Calif., as marketing manager. The division stresses the use of radiation in leak-detection systems and plans to market a line of applied-radiation products for industry.

Ranftl

Holmes & Narver has promoted **Kelly McBean,** manager of the Nuclear div., to vice-president. He will continue to direct a staff of specialists in reactor technology and regulations.

A new post at Argonne National Laboratory has been assigned to **Stephen Lawroski,** director of the Chemical Engineering div. He was named coordinator of engineering research and development programs, with responsibility for centralized planning, as well as coordination of engineering programs. With the job goes the chairmanship of ANL's Reactor Engineering Steering Committee; Lawroski will also retain his chemical engineering post.

Lawroski

Samuel J. Levine, formerly manager for test operation, General Electric Aircraft Nuclear Propulsion dept., Idaho Falls, has been shifted to Cincinnati headquarters of the department as manager of all projects and customer relations. He was succeeded at Idaho by **John W. Morfitt,** former manager of ANPD's nuclear development labs in Cincinnati. **Levine** was quickly further promoted to ANP chief (*page 31*).

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Stone & Webster has named **John J. Niland** assistant engineering manager to **M. H. Cutler.** Niland had been doing engineering administration work and serving, also, as assistant to the president of the Associated Nucleonics subsidiary.

In a management realignment at the top, Brush Beryllium has elected **Bengt R. F. Kjellgren** chairman and **George S. Mikhalapov** president. Kjellgren succeeds **C. Baldwin Sawyer,** who took over as chairman of the board's executive committee. The new chairman has been an officer of the firm since 1931; he holds 12 patents on developments in beryllium and piezoelectric crystals. Mikhalapov had been president of Coast Metals, Inc., Little Ferry, N. J., since 1954. From 1950–54, as an employee of General Electric, he had an important role in the design and construction of the Navy's second nuclear submarine—*Seawolf*. **Lawrence F. Boland** has been elected executive vice-president.

Kjellgren

Mikhalapov

C. D. Wagner has been named a research supervisor at Shell Development Co.'s Emeryville, Calif., research center, with responsibility for the radiation group of the Chemical Physics dept. **F. S. Mortimer** has been named research supervisor for molecular structure in the Spectroscopic dept.

AEC has shifted **John V. Vinciguerra** from his post as assistant manager at the Savannah River Operations Office to AEC headquarters—assistant director for safeguards, Division of International Affairs. He will manage the control system for fissionable material distributed overseas.

New staffers at Los Alamos Scientific Laboratory: **Edward Foley,** formerly of General Electric, engineer in the Test div.; **Beverly W. Washburn,** formerly of Space Technology Laboratories, an electrical engineer in the Test div.;

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NEWSMAKERS

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and **Marvin W. Rowe** and **James W. Evans,** respectively, biophysics technician in the Health div. and mathematician in the Theoretical div.

Choh-Yi Ang, a member of the P. R. Mallory research-and-development staff since 1954, has been appointed director of the firm's Materials Laboratories, Indianapolis. He will supervise research in neutron and gamma radiation, structural and electronic materials and processes, and heat-resistant and semiconducting intermetallics.

Ang

Pacific Coast Engineering Co. has named **Walter L. Treadwell** assistant general manager to **C. D. Ramsden,** president and general manager.

Wesley M. Johnson has been appointed deputy manager of AEC's New York Operations Office, under **Joseph C. Clarke.** Johnson had been assistant manager for technical operations; he will have over-all administration and operation responsibilities.

Sales personnel developments at three firms: **Werner A. Frey,** Zurich, will specialize in the European sale of radiation shielding windows for Corning Glass; **Gale M. Hallett** has been named sales manager, Charleston Rubber Co.; and **Richard F. Wood** has been named sales manager for atomic instruments, Baird-Atomic.

John M. Bodley, former legal aide to two Atomic Energy Commissioners (NU, March '59, 22), has joined Aerojet-General Corp. as special assistant to both **Dan A. Kimball,** president, and **William E. Zisch,** general manager. Bodley will handle special projects for A-G officers and represent the firm at meetings.

Bodley

Alan Walter has been named a senior research scientist at Isotopes, Inc., joining the firm from the National Physical Laboratory, England.

NUCLEAR CALENDAR

March 14–18—16th Annual Conference of National Assn. of Corrosion Engineers, Dallas. Nuclear session March 17. Contact NACE, 1061 M & M Bldg., Houston 2, Tex.

March 19–20—Direct conversion of nuclear energy, symposium of Pittsburgh section, American Nuclear Society, at Pittsburgh (*Mellon Institute*). Contact George Weddell, Westinghouse, Box 1468, Pittsburgh 30.

March 23–24—Symposium on Optical Spectrometric Measurements of High Temperatures, sponsored by Applied Science Laboratories of Univ. of Chicago, Jarrell-Ash Co. and National Science Foundation, Chicago (*Univ. of Chicago*). Program includes papers on plasma. Contact Frederick Brech, c/o Laboratories for Applied Science, Univ. of Chicago, 6220 S. Drexel Ave., Chicago 37, Ill.

March 29–31—22nd Annual American Power Conference, sponsored by Illinois Institute of Technology and several societies and schools, Chicago (*Sherman*). Contact R. A. Budenholzer, Mechanical Engineering dept., IIT, 3300 Federal St., Chicago 16.

March 30–31—Workshop on Industrial Uses of Radioisotopes, co-sponsored by Connecticut Power & Light, Hartford Electric Light, Housatonic Public Service, United Illuminating, AEC and Yale Univ., New Haven, Conn. (*Yale*). Contact E. B. Haskell, United Illuminating, New Haven 6.

April 3–8—6th Nuclear Congress, New York City (*Coliseum*). Includes 6th Nuclear Engineering & Science Conference, 8th Atomic Energy in Industry Conference and 6th International Atomic Exposition. Contact E. B. Gunyou, Curtiss-Wright Corp., Princeton, N. J.

Apr. 5—Meeting of Nuclear Representatives Assn., New York City. Contact Ben Z. Rubin, 16130 Meyers Rd., Detroit 35, Mich.

Apr. 19–22—International Symposium on the Metallurgy of Plutonium, Grenoble, France. Sponsored by French Society for Metallurgy. Contact Max Dupont, 25 rue de Clichy, Paris 9, France.

Apr. 20–22—12th Annual Southwestern Conference and Electronics Show, Institute of Radio Engineers, Houston (*Shamrock Hilton*). Schedule includes a Conference on National Medical Electronics. Contact SWIRECO, P. O. Box 22331, Houston 27, Tex.

May 3–6—Fuel Element Symposium sponsored by International Atomic Energy Agency, Vienna. **June 7–13**—IAEA Symposium on Radiation Dosimetry, Vienna. **Aug. 8–13**—IAEA Symposium on Ionizing Radia-

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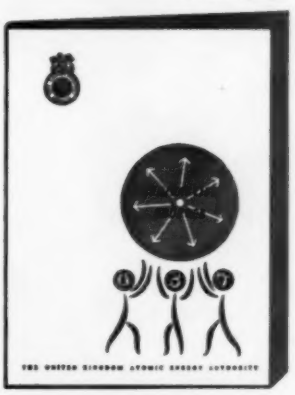

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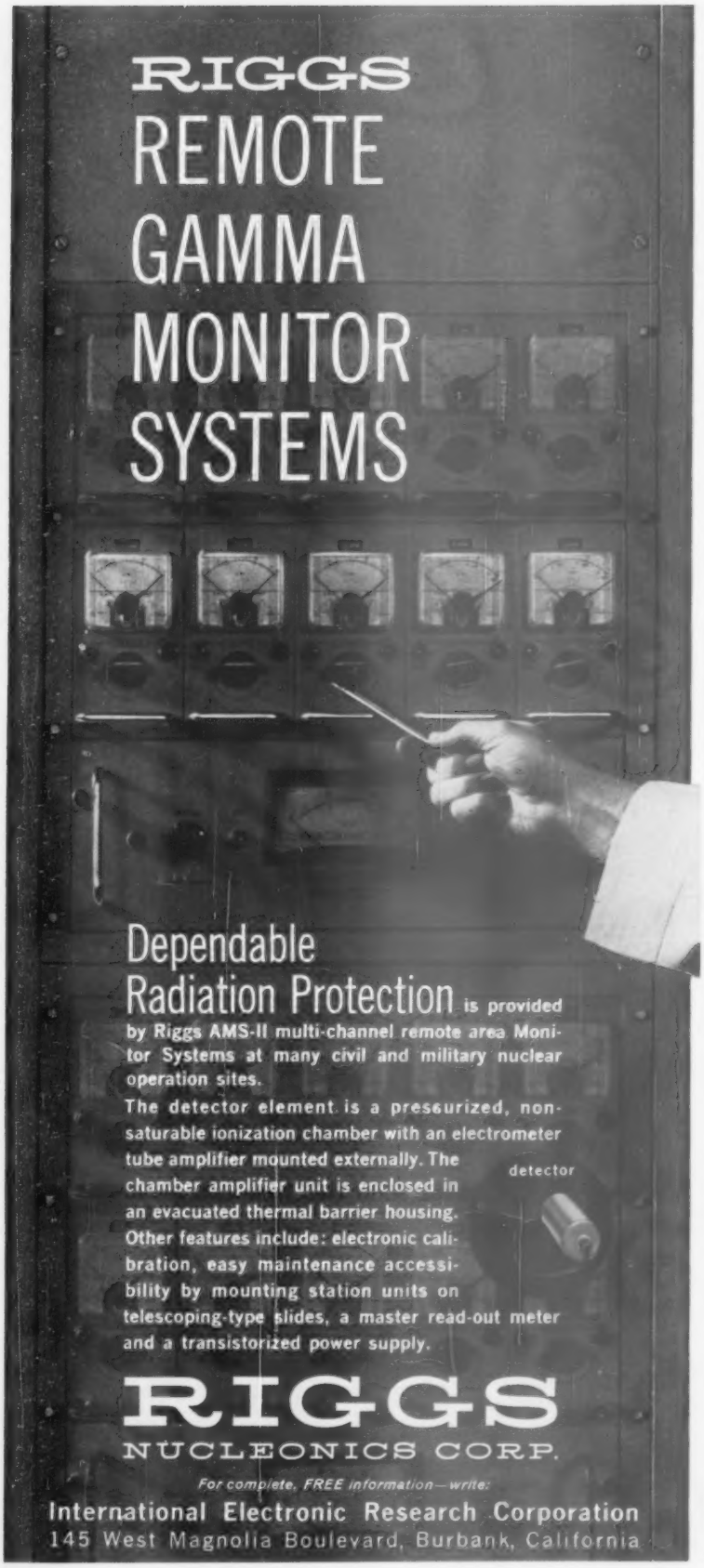
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NUCLEAR CALENDAR

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tion Effects on Seeds and Improvement of Crops, Karlsruhe, Germany. Contact IAEA, 11–13 Kartner Ring, Vienna 1.

May 9–13—Instrument Society of America, San Francisco. For papers on measurement and control instruments contact Martin E. Kantor, c/o General Atomic, P. O. Box 608, San Diego 12, Calif.

May 12—Advanced Propulsion Reactor concepts, unclassified session at American Rocket Society semiannual meeting, at Los Angeles (*Ambassador*). Contact C. J. Wang, c/o Space Technology Labs, Box 95001, Los Angeles 45.

May 24–26—1960 Convention of American Society for Quality Control, San Francisco. Contact ASQC, 161 W. Wisconsin Ave., Milwaukee, Wis.

June 12–15—Annual Meeting of American Nuclear Society, Chicago (*Palmer House*). Contact Octave J. DuTemple, 86 E. Randolph St., Chic. 1.

June 15–29—International Congress and Exhibition on Electronics, Nuclear Energy and Cinematography, Rome (*Palazzo dei Congressi*). Contact Evandro Benvenuti, Via della Scrofa, 14, Rome.

June 23–24—2nd Youth Conference on the Atom, Univ. of Michigan, Ann Arbor. Contact Bozell & Jacobs, 2 W. 45th St., N. Y. 36, N. Y.

June 29–July 1—Annual meeting, Health Physics Society, Boston (*Statler-Hilton*). Contact J. W. McCaslin, 1808 Rose St., Berkeley, Calif.

Aug. 11—AEC information meeting on small reactors, Oak Ridge. Contact R. A. Charpie, ORNL, Box 4, Oak Ridge.

Sept. 13–15—Fifth International Instruments and Measurements Conference, including section on nuclear instrumentation, and an exhibition of commercial instrumentation, Stockholm. Contact H. von Koch, Royal Institute of Technology, Stockholm 70, Sweden.

Dec. 11–16—American Nuclear Society–Atomic Industrial Forum joint meeting, San Francisco (*Mark Hopkins* and *Fairmont*). **12–15th** Atomfair West, first West Coast nuclear industrial exposition (*Masonic Memorial Building*). Contact W. Kelly Woods, Vallecitos Atomic Laboratory, Pleasanton, Calif., for ANS program; Edwin Wiggin, AIF, 3 E. 54 St., N. Y. 22, for Forum program; Dan Scherer, AIF, for Atomfair. **11–14**—8th Hot Laboratory and Equipment Conference. Paper summaries due May 16. Contact James R. Lilienthal, Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, N. M.

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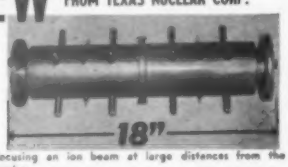

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NUCLEAR CAMPUS

CAMPUS FACILITIES. In its sixth series of **equipment grants** since late 1956, AEC has given 56 universities and colleges $1.8-million for the purchase of subcritical assemblies and other equipment. . . . **Auburn Univ.** is seeking $1,071,000 in donations for construction of a nuclear science center. . . . **Univ. of Wisconsin** has purchased a 10-kw pool reactor from General Electric; operational target date is this fall. . . . **Stevens Institute of Technology,** with the help of AEC funds, is adding a 1,000-curie cobalt-60 source, ion-exchange equipment and a radioactive separator to a subcritical reactor just being completed; Stevens also has an AEC contract to develop undergraduate experiments in plasma physics. . . . **Columbia Univ.** is using an AEC grant of $44,200 to purchase a deuteron accelerator and a multichannel analyzer for use with its two subcritical assemblies; also planned is purchase of a creep and relaxation machine for research on reactor metals. Columbia is offering the degree of nuclear engineer beginning with the 1960-61 academic year. . . . **California Institute of Technology** was nearing completion last month of an underground vault to house its fourth particle accelerator—a 10-Mev electrostatic machine paid for by the Office of Naval Research. . . . **Univ. of Texas** plans installation of a 12-Mev tandem electrostatic accelerator as the first major facility for its Science Research Institute; it will be completed in two years. The facility will also have several lower-energy accelerators.

CONTROLLED FUSION. Six research fellowships are available this summer —to Texas graduate students—for work in the controlled-fusion program at General Atomic div., General Dynamics. Co-sponsor of the research program is the Texas Atomic Energy Research Foundation (11 utilities).

COURSES. Three summer institutes in **radioisotope techniques,** sponsored jointly by AEC and the National Science Foundation, will be offered for six weeks each at: Oak Ridge Institute for Nuclear Studies, beginning July 24; Univ. of California, Berkeley, July 11; and Massachusetts Institute of Technology, June 20. The institutes were established for small-college faculty; 95 stipends are available covering family allowance, travel fee and living allow-

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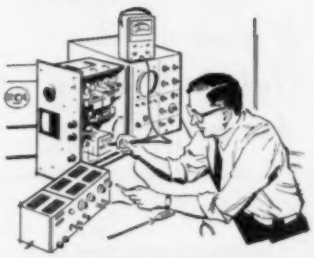

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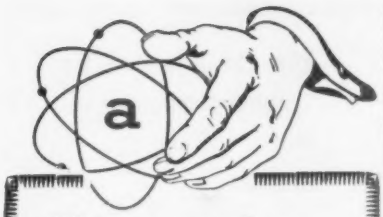

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NUCLEAR CAMPUS

Department starts on page 167

ance. . . . Illinois Institute of Technology is offering three nuclear-engineering courses in sequence—**laboratory measurement of radiation** this term, **reactor theory** in the fall, and a lab course in **reactor measurements** next spring. . . . Post-Graduate Medical School of New York Univ.-Bellevue Medical Center is offering **medical and public health control of ionizing radiation** March 7–18 and **radiation hygiene measurements** April 18–May 13.

Sacramento State College, Calif., is offering a summer institute on **non-destructive testing,** Aug. 15–26. Contact George N. Beaumariage, Jr., assistant professor of engineering, 6000 Jay St., Sacramento.

Louisiana State Univ. is offering, periodically, a 15-week seminar on **industrial application of radioisotopes** —for industrial personnel. Contact Harry D. Richardson, Engineering Laboratory Bldg., LSU, Baton Rouge.

AEC and the National Science Foundation have established a program of summer institutes for small-college faculty in **radioisotope techniques.** All institutes will run for 15 weeks; family, travel and living allowances are available. This summer's schedule: Oak Ridge Institute for Nuclear Studies, begins July 25; Massachusetts Institute of Technology, June 20; Univ. of California, Berkeley, July 11.

Robert A. Taft Sanitary Engineering Center, U.S. Public Health Service, is offering **reactor environmental health problems** May 16–25, centered on the health and safety aspects of reactors.

Univ. of California's fifth annual summer program in **nuclear technology** for executives, scientists, engineers and other technical personnel, begins June 6. The schedule: June 6–17, **basic radiological principles and techniques** (emphasis on ionizing radiation); June 2–July 15, **advanced radiological principles and techniques;** June 2–July 1, **criticality and criticality problems;** July 18–22, **nuclear technology survey —an executive review.**

Radiation Engineered Services is offering **nucleonics for the editor** March 15–17; registration fee, $25. Contact RES, Lafayette and Water Streets, Norristown, Pa.

The Organization for European Economic Cooperation is offering **nuclear energy for senior engineers and technical industrialists** at Saclay, France, June 27–July 8 and Harwell, U. K., July 4–15.

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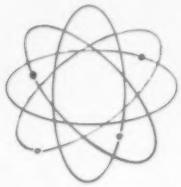

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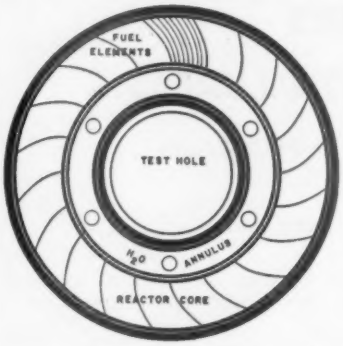

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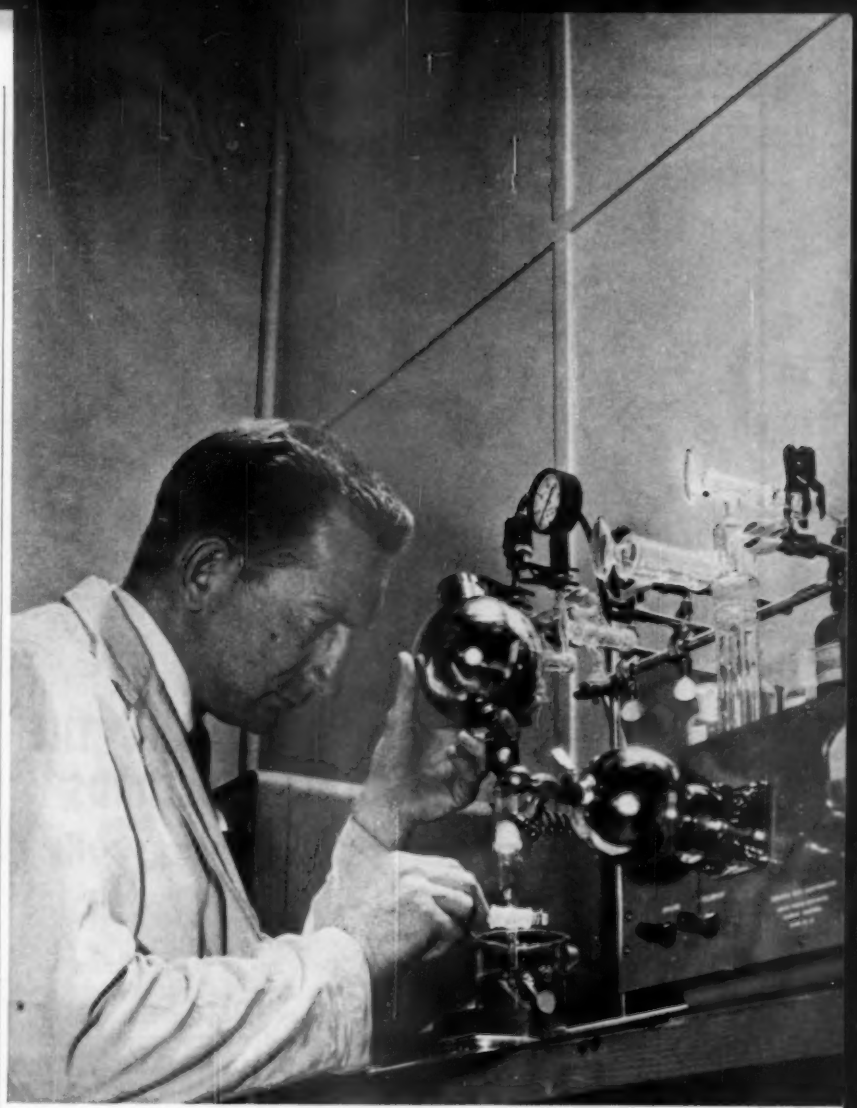

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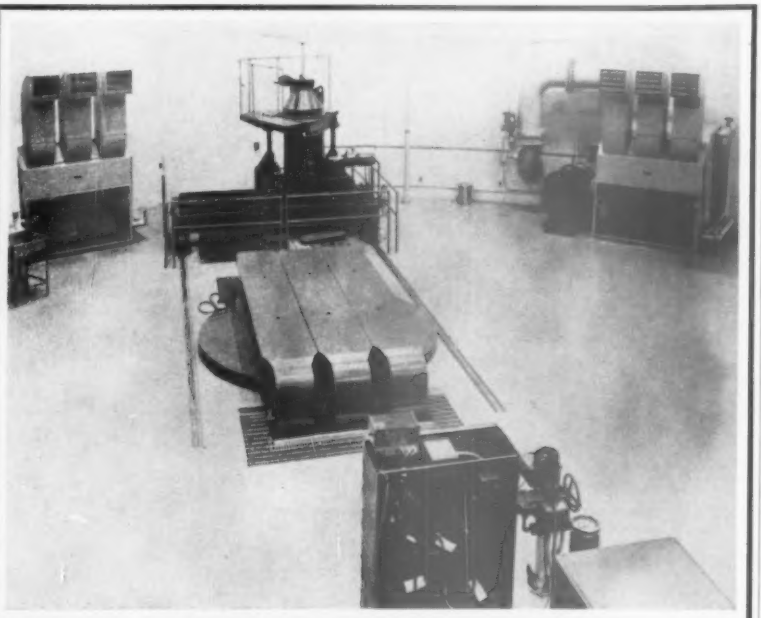

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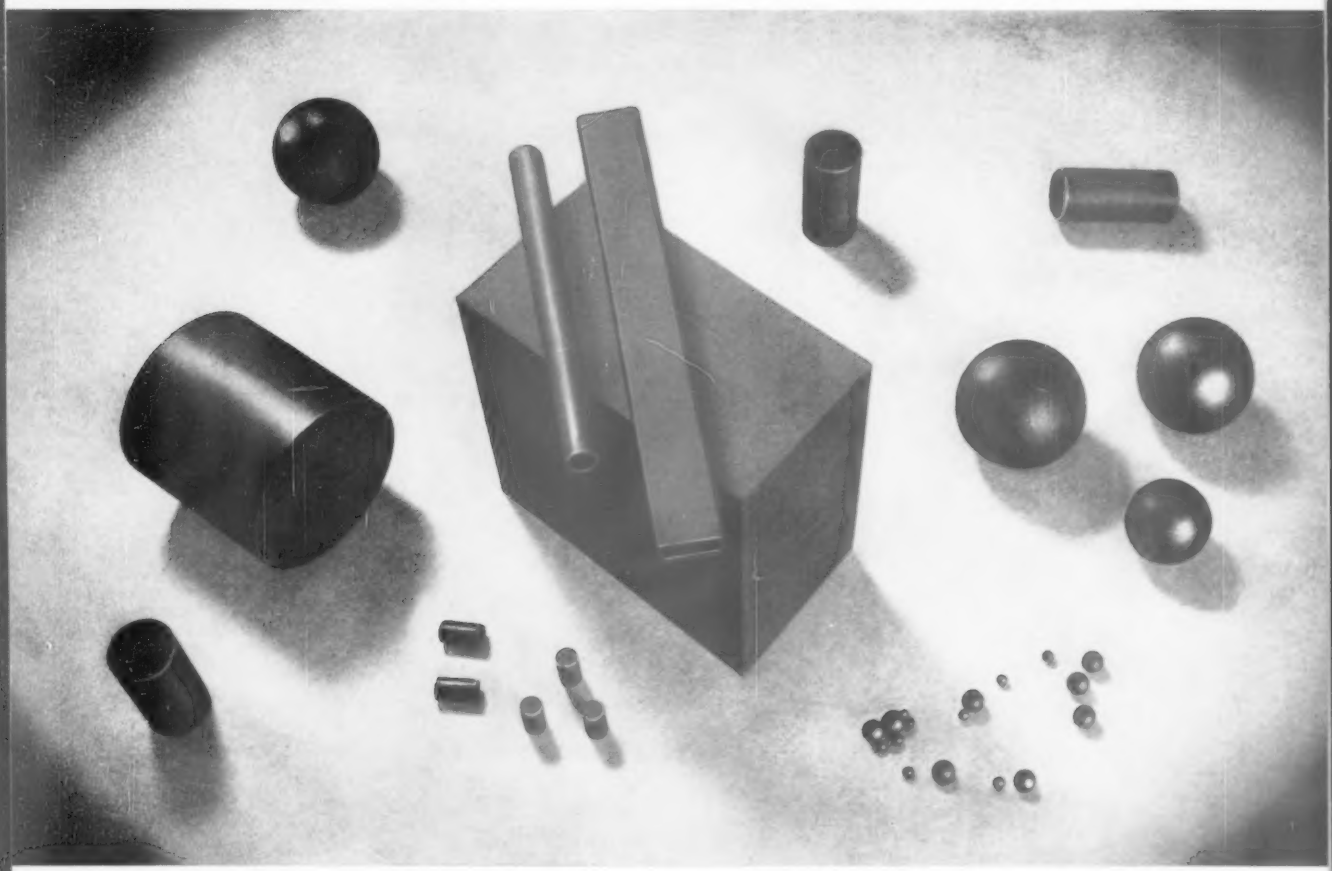

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